1975

Hampton bar dredging project, Newport News Shipbuilding and Dry Dock Co. borrow site, monitor of turbidity and sedimentation: final report

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HAMPTON BAR DREDGING PROJECT

NEWPORT NEWS SHIPBUILDING AND DRY DOCK CO. BORROW SITE

MONITOR OF TURBIDITY AND SEDIMENTATION

March, 1974 - February, 1975

Hampton, Virginia

FINAL REPORT

by

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SUMMARY OF FINDINGS

1. <u>Suspended Solids in the Water Column</u>:

   The water column adjacent to Hampton Bar normally contains approximately 5-15 mg/l of suspended solids during maximum current flows under light winds. Concentrations of 15-20 mg/l may occur with moderately strong winds as during a Northeaster. Relatively little stratification was evidenced; measured bottom concentrations were about 5-10 mg/l higher than surface concentrations during strength of flow in depths of 30 feet (outer flank of bar) with usually less of a difference being found in 10-foot depths (inner flank of bar).

2. <u>Increase in Suspended Solids Due to Dredging</u>:

   Dredging activity on Hampton Bar caused local increases in the level of suspended solids in the water column. Within plumes emanating from the hydraulic dredge during maximum flood, concentrations of 20-40 mg/l were typical, reaching levels of 50 mg/l and higher at distances of less than 400 yards from the dredge under normal conditions. Visible plumes approximately 400 yards wide and 4000 yards long were commonly observed in the Hampton Flats area during flood.

3. <u>Silt Curtain Effectiveness</u>:

   A silt curtain was deployed around the dredging unit to satisfy permit requirements. Observations made on several occasions revealed that the curtain, properly deployed, was not effective in retaining or restricting turbid emissions from the dredge. Moreover, considerable difficulties attended its deployment in any configuration during periods of moderate wave activity (seas 2-feet or more). Basically, it is our opinion that a silt curtain accomplishes very little in areas exposed to strong winds and currents since it causes only minor flow interruptions and achieves little or no separation of the suspended load under these conditions.

4. <u>Bottom Deposition due to Dredging</u>:

   Bottom deposition directly attributable to dredging activity was clearly evidenced within a 200-yard radius of the dredge, but was only indicated in one locality outside this range during a brief period of hydraulic dredging. The latter deposit consisted of one-quarter inch (6 mm) of fine bluish-gray silt lying unconformably over fine brown sand in three separate cores obtained September 23 and 24, 1974, near buoy sampling stations 7 and 8 at the west end of Hampton Flats. These stations were among several routinely sampled at approximately three-week intervals, during which an unconformity of the above type had not previously been observed.

The deposition in question did not appear to be sufficient to cause immediate harm to bottom-dwelling organisms but was considered a potential hazard should silt accumulations persist and increase in thickness. Notification to this effect was made to the appropriate authorities (NNS & DDCo. and Corps of Engineers). Subsequent sampling was conducted in the area, shortly after which the hydraulic dredge left the site for repairs. The silt layer did not persist beyond cessation of dredging.

5. Precautionary Measures - Dredging Restriction:
   Upon reaching bottom temperatures of 50°F or less, many benthic infauna enter a state of inactivity accompanied by low rates of metabolism. When the minimum was reached in late November of 1974, an opinion was given by VIMS biologists that any bottom accumulations caused by dredging could be fatal to organisms. A recommendation was made at this time, based on observed patterns of emissions transport and dispersal, that dredging be restricted to the ebb phase of the tidal current cycle. This recommendation was adopted and placed in effect until the end of the dredging project in February, 1975. Bottom monitoring during the period of the restriction revealed no discernable accumulations.

6. Dissolved Oxygen Levels:
   Dissolved oxygen was measured at different depths in the water column, including maximum depths found in local depressions remnant from dredging. All of the samples indicated D.O. values at or near saturation levels, including those in depressions on Hampton Bar up to 25 feet deep left after termination of the project.

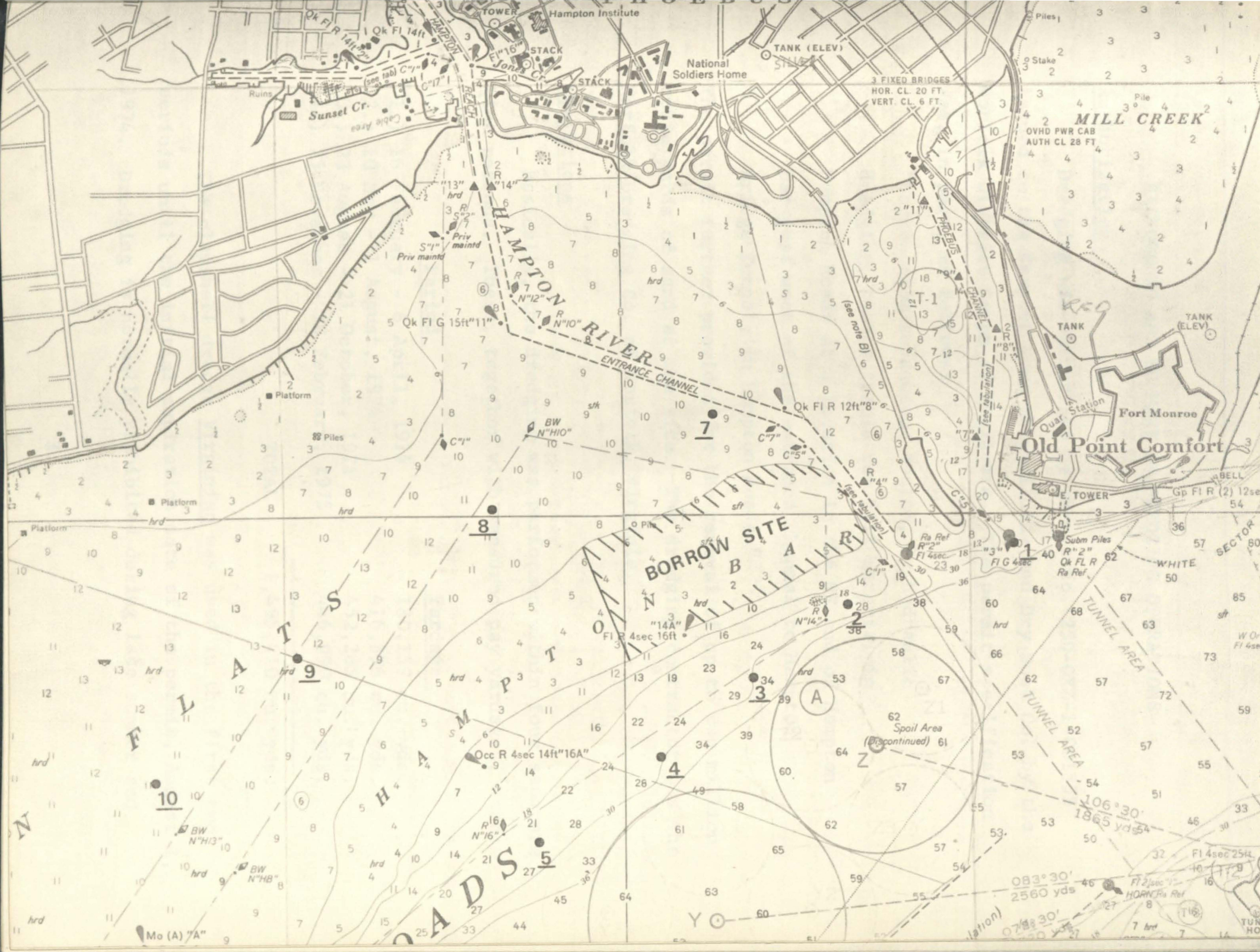
7. Comparative Analysis of Dredging Methods:
   Dredging of Hampton Bar was initially conducted by a clamshell dredge which was later replaced by a hydraulic dredge. Both machines filled scows for removal by tow vessels. Overflow emissions from scows filled by the clamshell dredge contained average solids concentrations of 4.5 g/l whereas those later emitted during hydraulic dredging averaged 32.8 g/l. Measured emission rates obtained during the hydraulic dredging operation indicated that approximately 25-30% of the total volume of solids removed from the bottom was returned to the environment in the overflow.

INTRODUCTION

This report summarizes field observations and sedimentological findings made by the Virginia Institute of Marine Science while monitoring a dredging project on Hampton Bar at Hampton, Virginia (Figure 1). Monitoring was conducted at the request of the Newport News Shipbuilding and Dry Dock Co. of Newport News, Virginia, for the purpose of assessing localized effects of the dredging operation on a real time basis so that operational decisions could be made to mitigate adverse impacts or prevent their occurrence.

The immediate source of concern during the dredging operation was the potential impact of fine sediments introduced into the water column upon separation from recovered fill materials. The rate of release of fines, their subsequent history of movement and dispersal, and the tendency to accumulate in locally significant quantities on the bottom were the primary factors considered. In particular, the accumulation of fine sediment in any significant quantity on undisturbed bottom even for a brief period, was considered a potential hazard to shellfish and other bottom-dwelling organisms in the vicinity of Hampton Bar. In addition, attention was given to water-quality degradation which might have ensued depending upon the organic content of the released material and its tendency to reduce dissolved oxygen levels. The risk of the latter occurrence is especially real in isolated deep depressions in the bottom where circulation and water exchange are minimal.

FIGURE 1. Section of NOS chart 400 showing Newport News Shipbuilding and Dry Dock Co. borrow site (hatched area) and location of buoy stations.



TOWER
Hampton Institute
TANK (ELEV)
National Soldiers Home
STACK
Qk Fl R 14ft"2"
Qk Fl 14ft
HAMPTON REACH
Fl"16"
Jones Cr.
Ruins
Sunset Cr.
Cable Area
3 FIXED BRIDGES
HOR. CL. 20 FT.
VERT. CL. 6 FT.
MILL CREEK
OVHD PWR CAB
AUTH CL 28 FT
Piles
Stake
Pile
HAMPTON RIVER
ENTRANCE CHANNEL
Priv maintd
Qk Fl G 15ft"11"
PHOEBUS CHANNEL
(see note B)
(see tabulation)
T-1
TANK
TANK (ELEV)
Platform
Piles
BW N"HIO"
Qk Fl R 12ft"8"
Quar Station
Fort Monroe
Old Point Comfort
E. TOWER
BELL
Gp Fl R (2) 12sec
BORROW SITE
BAR
Ra Ref
Fl 4sec
Fl G 4sec
Subm Piles
Qk FL R
WHITE SECTOR
"14A"
Fl R 4sec 16ft
TUNNEL AREA
FLATS
HAMPTON ROADS
Spoil Area
(Discontinued)
Occ R 4sec 14ft"16A"
106°30'
1865 yds
083°30'
2560 yds
BW N"H13"
BW N"HB"
Mo (A) "A"
Fl 4sec 25ft
HORN Ra Ref

BACKGROUND AND SUMMARY OF DREDGING OPERATIONS

Authorization

Dredging was authorized by permit No. 25D-OXZ-1-001555 issued to the Newport News Shipbuilding and Dry Dock Co. by the Norfolk District Corps of Engineers. The permit specification was, in part, as follows:

> "Borrow from subaqueous bottom, by hydraulic dredging, sand suitable for fill material in Hampton Roads at a location in the NE end of Hampton Bar just west of the entrance channel to Hampton Bridge Tunnel, in Hampton Roads."

The permit further provided for the removal of up to two million cubic yards of sand at the site. The dredging contractor was the Norfolk Dredging Co. of Norfolk, Virginia.

Operations

Basically, the dredging was performed within four separate time periods. These, together with measured pay yardages, were:

Period	Yardage
1.) 16 February - 6 April, 1974	180,159 cu. yds.
2.) 10 May - 1 August, 1974	416,896 cu. yds.
3.) 22 August - 21 October, 1974	452,265 cu. yds.
4.) 25 November - 10 February, 1975	446,090 cu. yds.
TOTAL	1,495,410 cu. yds.

The clamshell dredge Virginian was used in the first two periods until the initial expiration date of the permit, August 1, 1974. Dredging is normally prohibited during late summer and fall (until October 1) near active oyster beds to avoid interference with striking oyster spat. A time extension was granted to complete the project. Dredging was continued using the hydraulic dredge Talcott which was unavailable until this time. The remaining hiatuses between dredging periods resulted when the dredges were away for repairs.

Bottom material removed by both dredges was loaded onto scows equipped with overflow downpipes through the bottom and bleeder pipes at the gunnels. The clamshell dredge simply scooped material from the bottom and released each charge into the scow, allowing the excess water and fine sediment to run overboard. The hydraulic dredge pumped a water and sand mixture or "slurry" through an outfall pipe to a spreader barge stationed about 200 yards away from the dredge; scows were then filled after securing in turn under the multiple exit ports of a large manifold device mounted on the spreader barge. Further description of the scow filling operation and overflow emissions will be given later in this report.

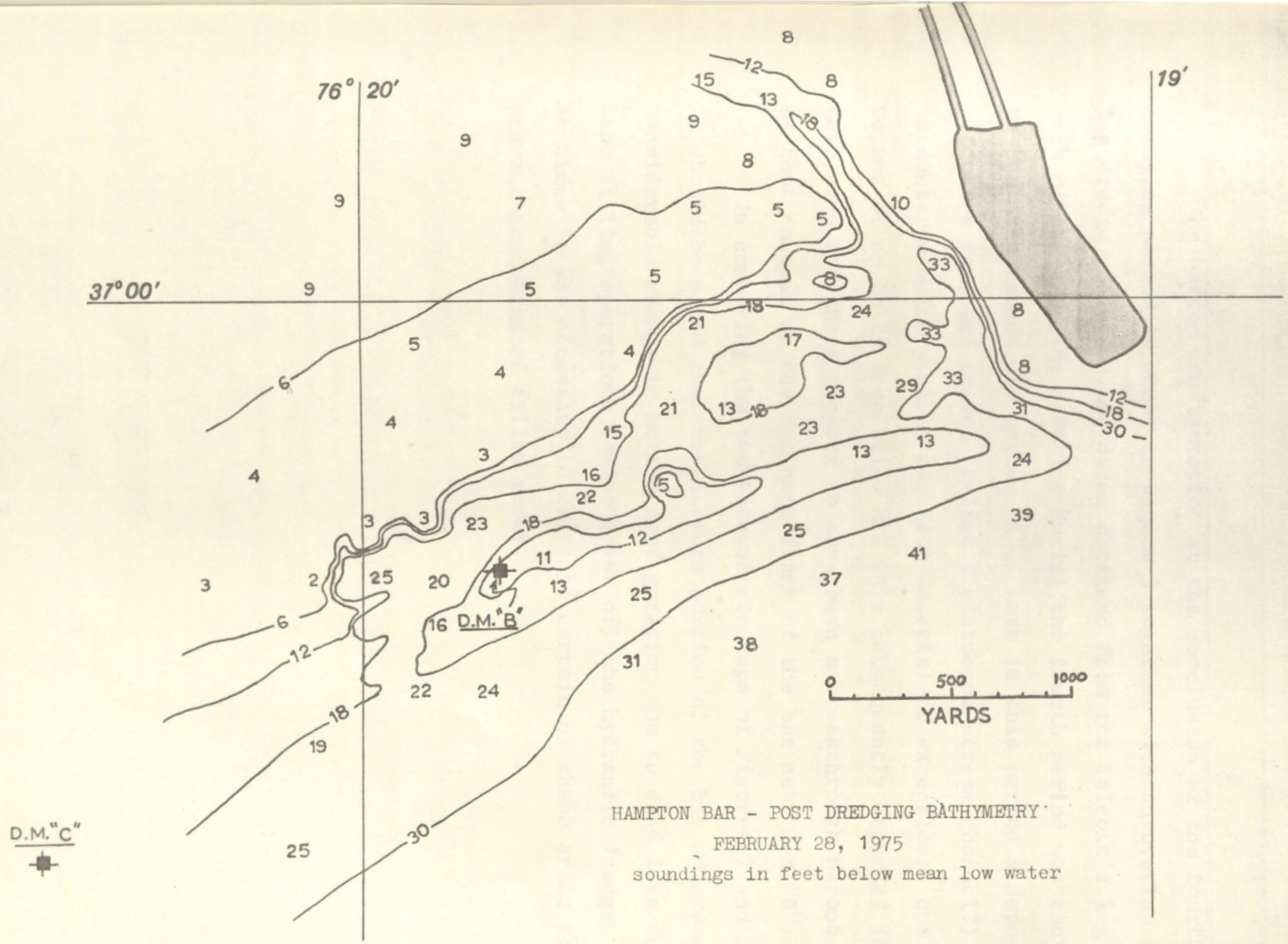
CHANGES IN BATHYMETRY OF HAMPTON BAR

Most of the dredging performed during the first two periods by the clamshell dredge was restricted to the extreme eastern end of Hampton Bar (Figure 1). During the third and fourth periods, the hydraulic dredge ranged farther to the west along the south-central axis of the bar.

Post-dredging bathymetry was conducted at the conclusion of the third and fourth periods on October 30, 1974 and February 28, 1975. The bathymetry was determined from soundings obtained on parallel sounding lines and crosslines. Positions were marked at approximately two minute intervals along each line using the three-point fix method and horizontal sextant angles. Depths were recorded using a Raytheon DE-719 precision survey fathometer and scaled at regular intervals on and between fixes for reduction to MLW values before plotting and contouring.

Figure 2 shows the post-dredging bathymetry of the bar following the third dredging period. Note that the dredge at this time had cut westward to a point just inside day marker "B" which marks the seaward position of the six-foot contour around Hampton Bar. Thus, there remained at this time a shallow level between the dredged area and the seaward (southern) flank of the bar which grades into an active clamming area at depths of between 20 and 40 feet. Inside the bar the maximum depth of dredging was approximately 20 feet below MLW except near the entrance channel to Hampton Creek.

Figure 2. Post-dredging bathymetry, October 30, 1974
Hampton Bar.

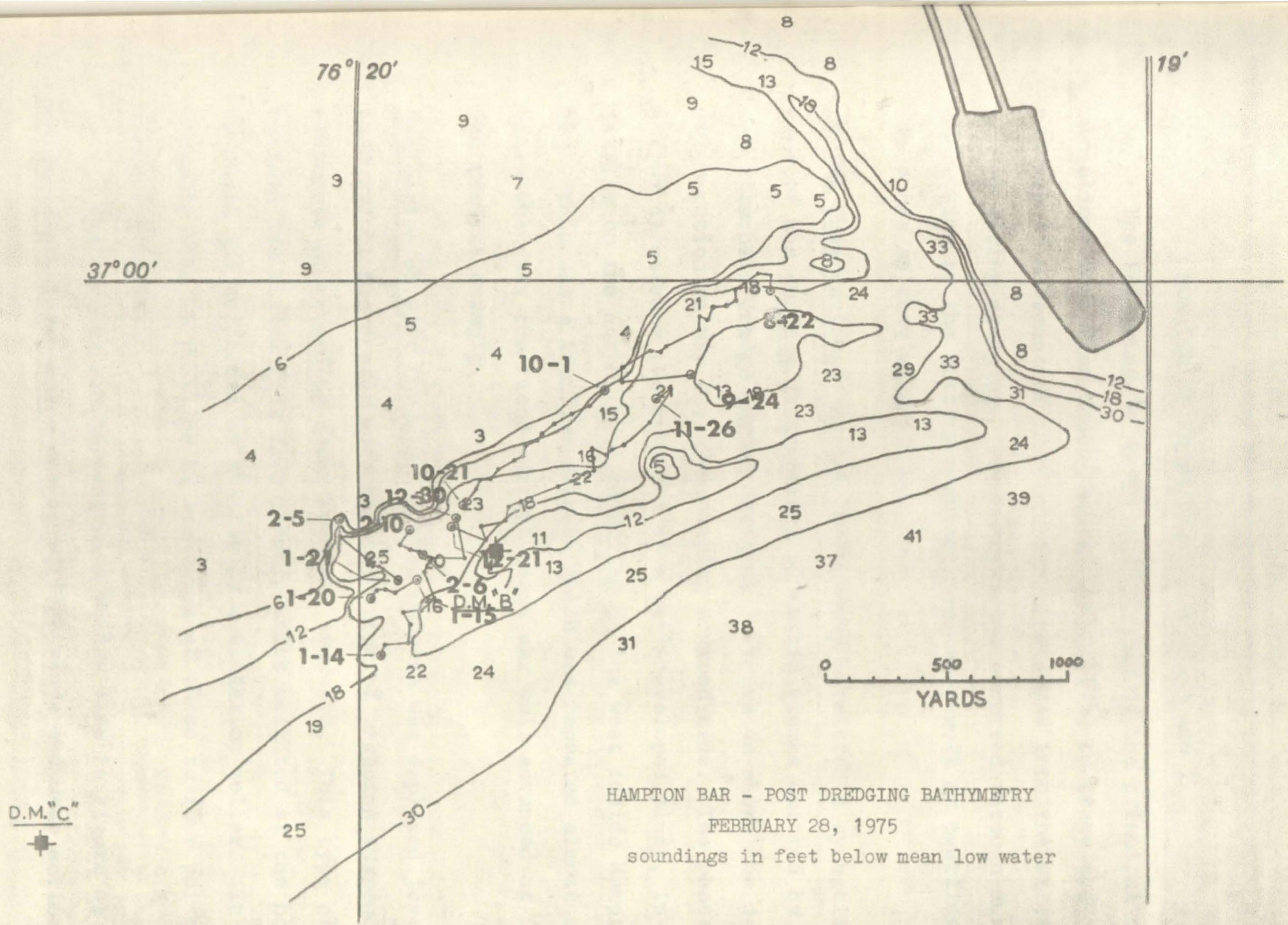


HAMPTON BAR - POST DREDGING BATHYMETRY
FEBRUARY 28, 1975
soundings in feet below mean low water

The bottom configuration at the conclusion of the fourth dredging period is shown in Figure 3 together with an overlay showing dredge positions and dates obtained from the Talcott's log. Much of the dredging activity during the fourth period was confined to the area around day marker "B". Late in this period a deposit of coarse sand and gravel (relict Pleistocene stream channel?) was encountered which yielded backfill material of exceptional quality. Depths of up to 25 feet below MLW were subsequently recorded in this area and there appears to have been a breakthrough beyond the 18-foot contour on the southern flank of the bar near D.M."B".

In comparing the two bathymetric maps of Figures 2 and 3 it should be noted that the eastern portion of the bar underwent considerable change in bottom configuration due to sand loss during scow filling operations behind (east of) the hydraulic dredge. At times it was necessary to redredge certain of these areas to prevent grounding of filled scows.

Figure 3. Post-dredging bathymetry, February 28, 1975, Hampton Bar. Overlay shows dated positions of dredge from August 22, 1974 through February 10, 1975.



HAMPTON BAR - POST DREDGING BATHYMETRY

FEBRUARY 28, 1975

soundings in feet below mean low water

MONITOR OF EMISSIONS - PERIODS 1 AND 2

The following is an account of some of the principal observations made from March through July, 1974, to trace the history of movement of fine sediments released into the water column during dredging. These emissions occurred through direct suspension by the cutting machinery and as runoff or overflow from the scows as they were filled.

Aerial Observations: Aerial photography permitted a synoptic view of the surface distribution of turbid plumes emitted by the clamshell dredge during dredging. Figure 4a shows the dredge in operation on May 22, 1974, during a flood tide. The photographs illustrate the movement of a well-developed plume, initially to the north, then recurving to the west inside Hampton Bar. This was a familiar pattern which was repeated almost exactly whenever the flood current phase was well advanced as in the present example.

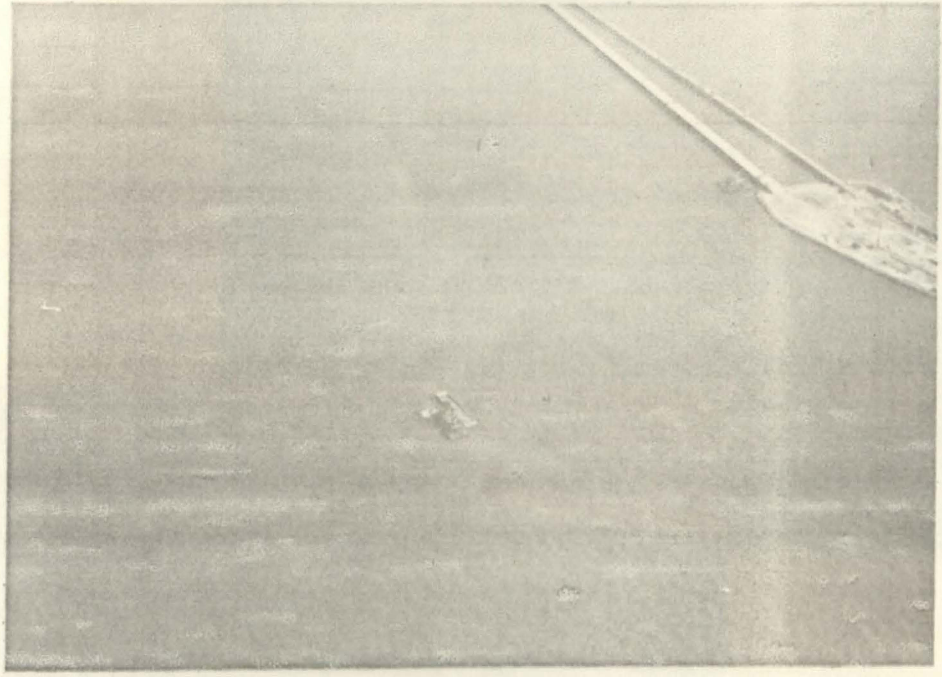
Evaluation of Silt Curtain: A silt curtain was deployed just landward of the dredge with the intention of trapping suspended sediments or retarding their movement landward. This type of curtain has a five-foot deep plastic skirt weighted at the bottom by chain and supported at the top by a flotation collar. It is normally held in position by anchoring at three to four points along its length.

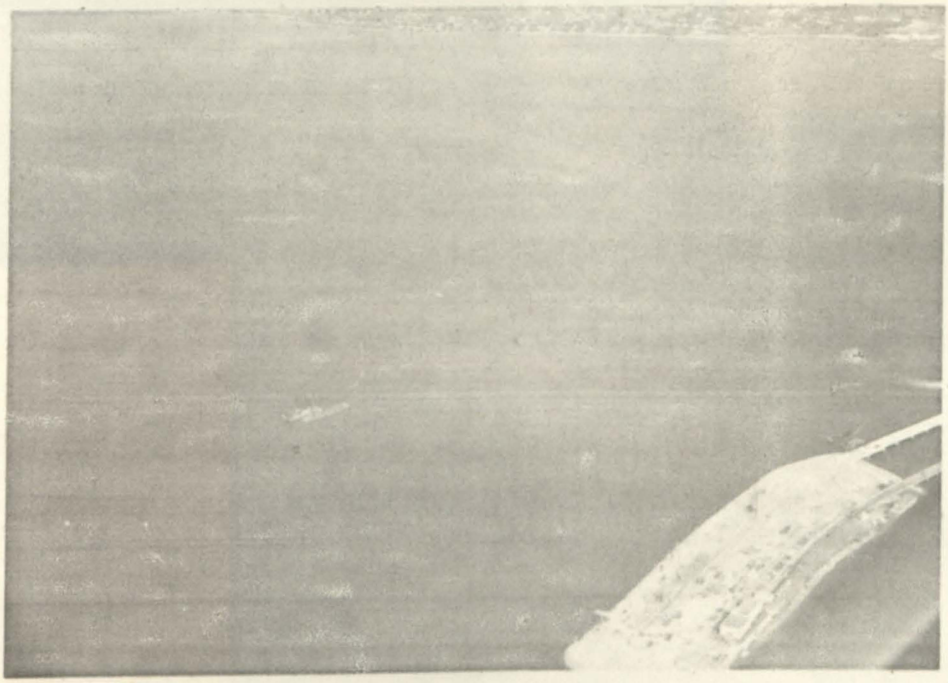
The curtain can be seen as a yellow line in Figure 4a having a scalloped shape due to surface winds and wave action

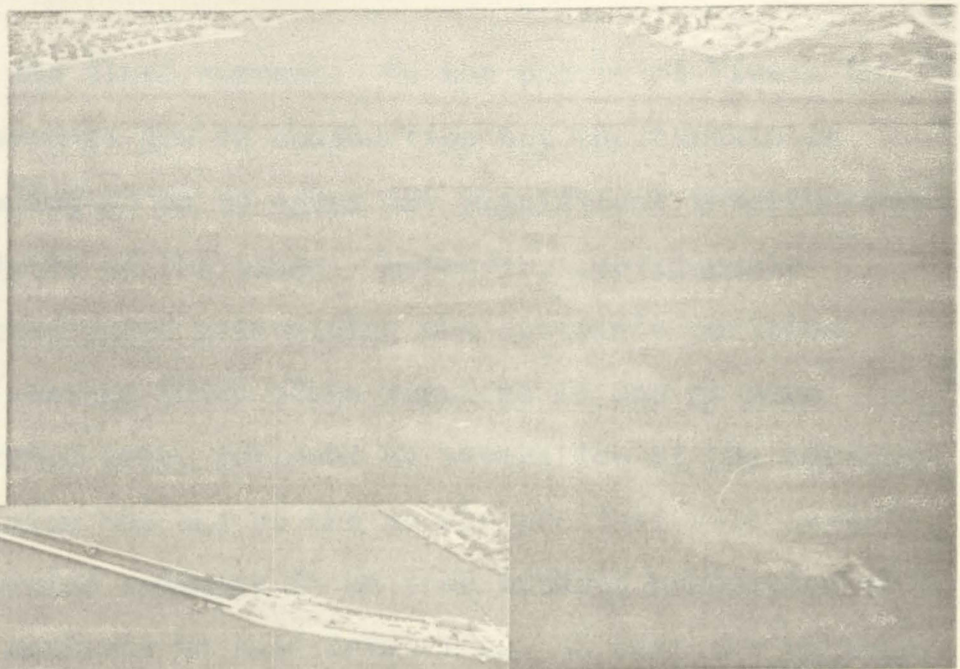
Figure 4. Aerial oblique photographs showing clamshell dredge Virginian in operation on Hampton Bar:

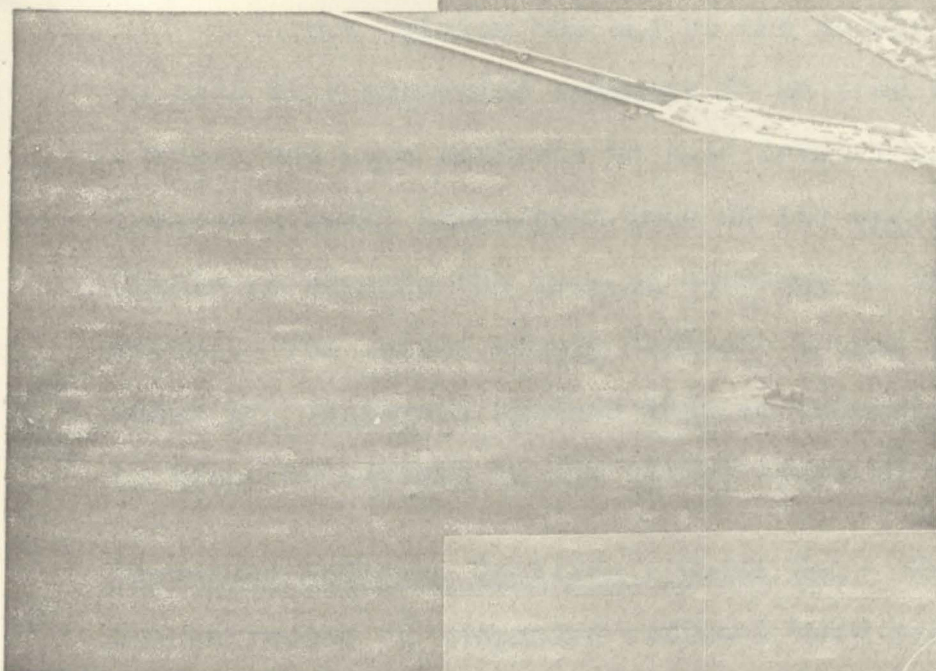
a) May 22, 1974, during mid-flood;

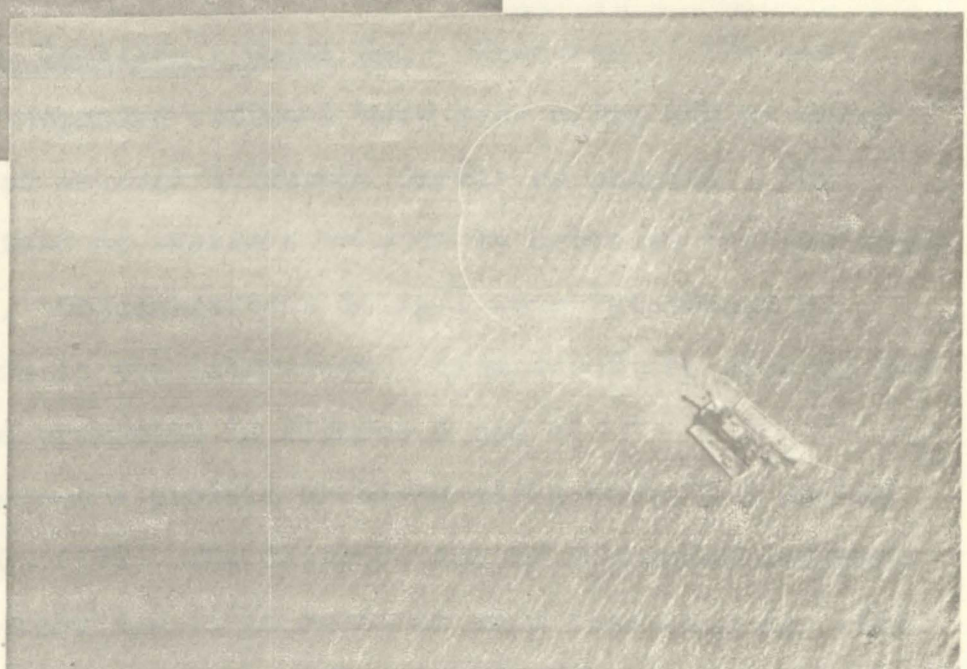
b) June 4, 1974, during late flood.











in opposition to the flood current. In the photos of Figure 4b, wind waves and currents are in conjunction but the curtain is still not functioning so as to cause any significant interruption in the westward drift of the plume. Moreover, considerable difficulty was experienced maintaining the curtain's position during inclement weather which often resulted in one or more anchors being carried away, followed by separation of the curtain.

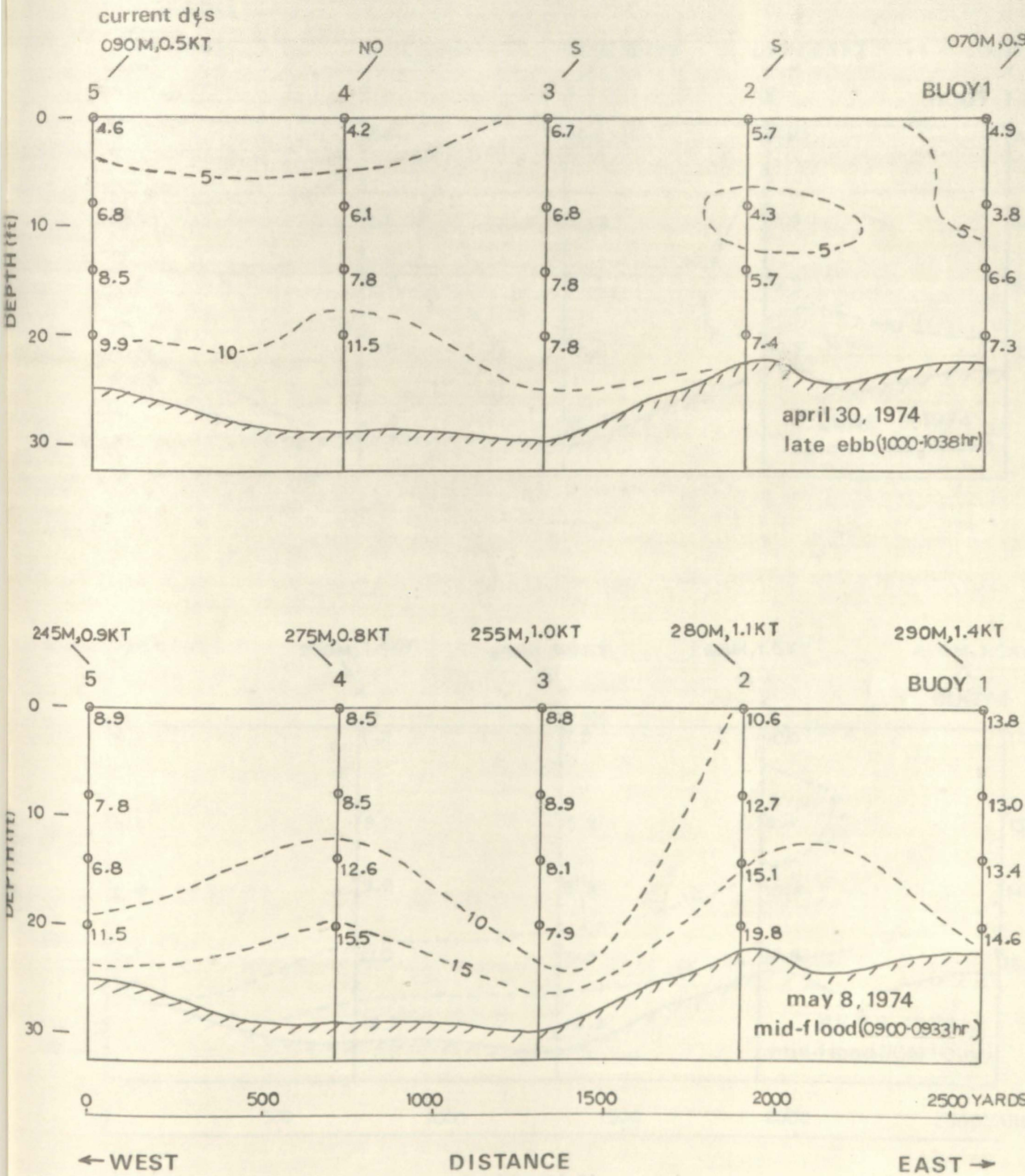
In our opinion the use of the above-described silt curtain to trap fine suspended sediment in an area without protection from current and wave activity is self-defeating. At best the curtain creates a small stagnation zone on its updrift side which will do little to advance the rate of settling of the bulk of the suspended matter. The latter simply deflects around the curtain or moves under it. Balanced against this is the constant attention required to keep the curtain in any useful state of deployment.

Suspended Sediment Profiles - Outer Bar: Measures of the mass concentration of suspended sediment were made using 400 ml water samples obtained at several different depths by pumping. The samples were obtained at stations located by buoys at the positions shown in Figure 1. Concentrations in mg/l were determined by gravimetric methods in the laboratory. Examplesof the plotted and contoured data are presented in Figures 5 and 6.

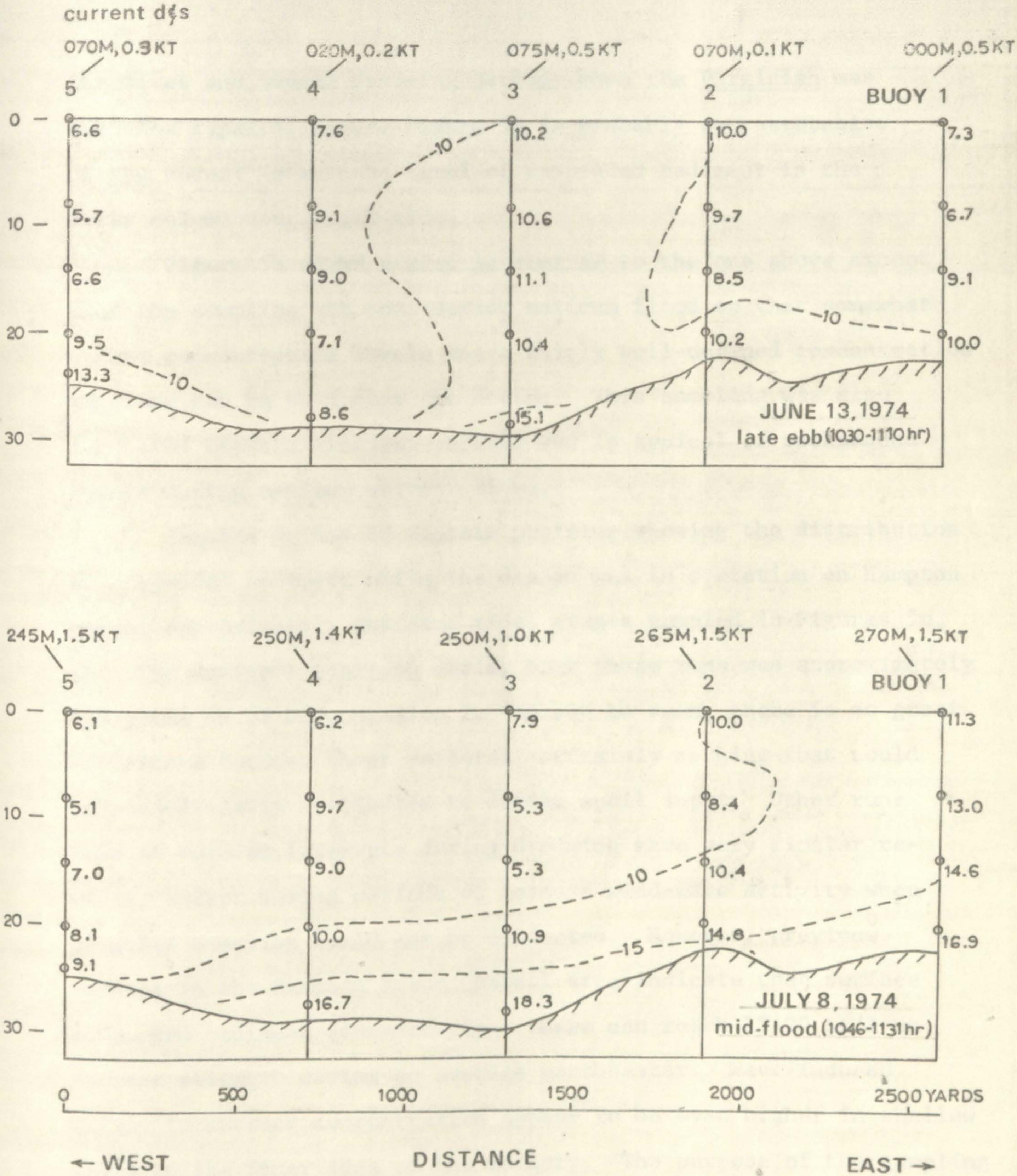
Figure 5a shows a profile obtained along buoys 1-5 during late ebb, April 30, 1974. The distribution of suspended sediment was uniform and rather low (5-10 mg/l) at this time on a day with no wind and a calm sea. This sampling was also conducted between

Figure 5. Profiles of suspended sediment concentration, buoys 1-5, Hampton Bar:

a) April 30, 1974, during late ebb, no dredging;
b) May 8, 1974, during mid-flood, no dredging;
c) June 13, 1974, during late ebb, with dredging;
d) July 8, 1974, during mid-flood, with dredging.



current d&s
090M,0.5KT
NO
S
S
070M,0.9KT
5
4
3
2
BUOY1
0
10
20
30
DEPTH (ft)
4.6
6.8
8.5
9.9
4.2
6.1
7.8
11.5
6.7
6.8
7.8
7.8
5.7
4.3
5.7
7.4
4.9
3.8
6.6
7.3
5
10
april 30, 1974
late ebb(1000-1038hr)
245M,0.9KT
275M,0.8KT
255M,1.0KT
280M,1.1KT
290M,1.4KT
BUOY 1
8.9
7.8
6.8
11.5
8.5
8.5
12.6
15.5
8.8
8.9
8.1
7.9
10.6
12.7
15.1
19.8
13.8
13.0
13.4
14.6
10
15
may 8, 1974
mid-flood(0900-0933hr)
0
500
1000
1500
2000
2500 YARDS
← WEST
DISTANCE
EAST →



070M, 0.3KT
020M, 0.2KT
075M, 0.5KT
070M, 0.1KT
000M, 0.5KT
5
4
3
2
BUOY 1
DEPTH (ft)
0
10
20
30
6.6
5.7
6.6
9.5
13.3
7.6
9.1
9.0
7.1
8.6
10.2
10.6
11.1
10.4
15.1
10.0
9.7
8.5
10.2
7.3
6.7
9.1
10.0
10
JUNE 13, 1974
late ebb (1030-1110 hr)
245M, 1.5KT
250M, 1.4KT
250M, 1.0KT
265M, 1.5KT
270M, 1.5KT
6.1
5.1
7.0
8.1
9.1
6.2
9.7
9.0
10.0
16.7
7.9
5.3
5.3
10.9
18.3
10.0
8.4
10.4
14.8
11.3
13.0
14.6
16.9
15
JULY 8, 1974
mid-flood (1046-1131 hr)
0
500
1000
1500
2000
2500 YARDS
← WEST
DISTANCE
EAST →

the first and second dredging periods when the Virginian was away for repairs; hence, Figure 5a is probably representative of the normal background level of suspended sediment in the water column near slack tide.

Figure 5b shows a profile similar to the one above except that the sampling was done during maximum flood so that somewhat higher concentration levels and a fairly well-defined concentration gradient can be seen near the bottom. This sampling was also conducted between dredging periods and is typical of background levels during maximum current flows.

Figures 5c and 5d contain profiles showing the distribution of suspended sediment while the dredge was in operation on Hampton Bar at approximately the same tidal stages sampled in Figures 5a, 5b. The dredge's position during both these runs was approximately 500 yards NW of buoy station 2. As can be seen, there is no great difference between these patterns, certainly nothing that could be unequivocably attributed to dredge spoil input. Other runs made at regular intervals during dredging gave very similar results, except during periods of intense wind-wave activity when detailed sampling could not be conducted. However, previous studies in the Hampton Roads Channel area indicate that surface suspended sediment concentrations there can reach 15-20 mg/l at current strength during an average northeaster. Wave-induced maxima in surface concentration appear to be even higher in shallow areas at the inner edge of the estuary. The purpose of the sampling along buoys 1-5 was, however, aimed at detecting anomalous concentrations levels along the outer flank of Hampton Bar which is an important shellfishing ground.

Dissolved Oxygen Distribution - Outer Bar: Dissolved oxygen was measured in duplicate samples taken during several of the suspended sediment runs at buoys 1-5. As previously mentioned, the purpose of this sampling was to determine whether organic material released from dredged bottom sediments were causing a depression of normal D.O. levels in the water column. Attention was first given to the outer flank of Hampton Bar because of the commercially valuable hard clam population found in this area.

Table 1 contains D.O. data for three separate runs made during late ebb, mid-flood, and late flood, respectively. There are no apparent anomalies in these data, all values being very close to saturation levels for the prevailing temperatures and salinities during each run.

Suspended Sediment Distribution - Inner Bar: Buoys 7-10 were installed at the positions shown in Figure 1 for repetitive sampling of the water column and bottom along the inner (landward) side of Hampton Bar. Buoy 6, located at the extreme west end of the bar, was lost soon after its installation and was not reestablished.

Table 2 contains suspended sediment concentration data for the inner bar during selected sampling runs. The initial run on May 8 occurred during a period when the dredge was away for repairs. The remaining sampling runs were made while the

TABLE 1. Dissolved Oxygen ($mgO_2/1$), Buoys 1-5, Outer Flank, Hampton Bar

6/13/74 - Late Ebb

Buoy	1	2	3	4	5
Surface	9.06	9.00	8.72	9.04	8.48
+ 8'	7.83	7.79	8.38	9.23	7.83
+14'	7.95	6.90	7.64	9.04	7.71
+20'	7.75	6.59	6.98	7.89	8.42
Bottom	--	--	6.69	7.95	7.48

6/13/74 - Mid-Flood

Buoy	1	2	3	4	5
Surface	8.31	8.40	7.02	8.62	7.58
+ 8'	8.42	8.03	8.34	8.64	9.59
+14'	7.77	8.29	8.42	8.15	8.78
+20'	7.81	7.99	7.81	8.25	8.46
Bottom	--	--	8.21	8.21	8.11

7/8/74 - Late Flood

Buoy	1	2	3	4	5
Surface	6.99	6.32	6.91	6.55	6.50
+ 8'	6.54	6.85	3.99	5.98	6.26
+14'	6.04	6.16	5.92	6.25	6.38
+20'	6.06	5.78	6.34	5.74	5.84
Bottom	--	--	5 24	5.50	5.74

TABLE 2. Suspended Sediment Concentrations (mg/l), Buoys 7-10, Inner Flank, Hampton Bar

5/8/74 - Mid-Flood

Buoy	7	8	9	10
Surface	7.6	7.5	6.6	6.3

6/13/74 - Mid-Flood

Buoy	7	8	9	10
Surface	7.2	7.2	9.3	9.6
Bottom	7.1	5.6	8.0	7.5

7/8/74 - Mid-Flood

Buoy	7	8	9	10
Surface	18.2	4.8	8.4	11.3
Bottom	10.6	22.4	7.8	11.4

7/8/74 - Late Flood

Buoy	7	8	9	10
Surface	3.6	4.2	3.5	5.3
Bottom	7.6	5.0	10.6	5.5

dredge was operating. These and other data indicate that a background level of 3-10 mg/l is usual in normal weather. Occasional readings of 18-20 mg/l were observed at buoys 7 and 8 when part of the dredge plume intercepted these stations. During the operation of the clamshell dredge, however, it did not appear that very high sediment loadings were reaching any of the buoy stations. Samples obtained at distances of about 100 yards downdrift from the dredge contained between 8-15 mg/l usually; the maximum value found was 27.6 mg/l in a surface sample within the plume.

Dissolved Oxygen Distribution - Inner Bar: A partial tabulation of the D.O. readings obtained at buoys 7-10 is presented in Table 3. All of the readings are close to the saturation level for the temperature and salinity prevailing. Samples collected about 100 yards from the dredge also had normal readings.

Overflow Mass Concentration and % Organics:

Excess water and entrained fine sediment was periodically sampled as it left the scows being filled by the dredge; 400 ml samples were collected by Norfolk dredging personnel at the beginning of overflow and shortly after completion of filling of each scow. The samples were subsequently analyzed at VIMS for total suspended sediment concentration in mg/l and % organics by ignition loss.

Figures 6 and 7 are bar graphs showing the daily average concentration of the overflow broken into two groups: initial and final. Initial overflow refers to the first few minutes of over-

TABLE 3. Dissolved Oxygen (mgO_2/l), Buoys 7-10, Inner Flank, Hampton Bar

6/13/74 - Mid-Flood

Buoy	7	8	9	10
Surface	9.61	9.45	9.67	9.53
Bottom	8.52	8.27	9.04	9.86

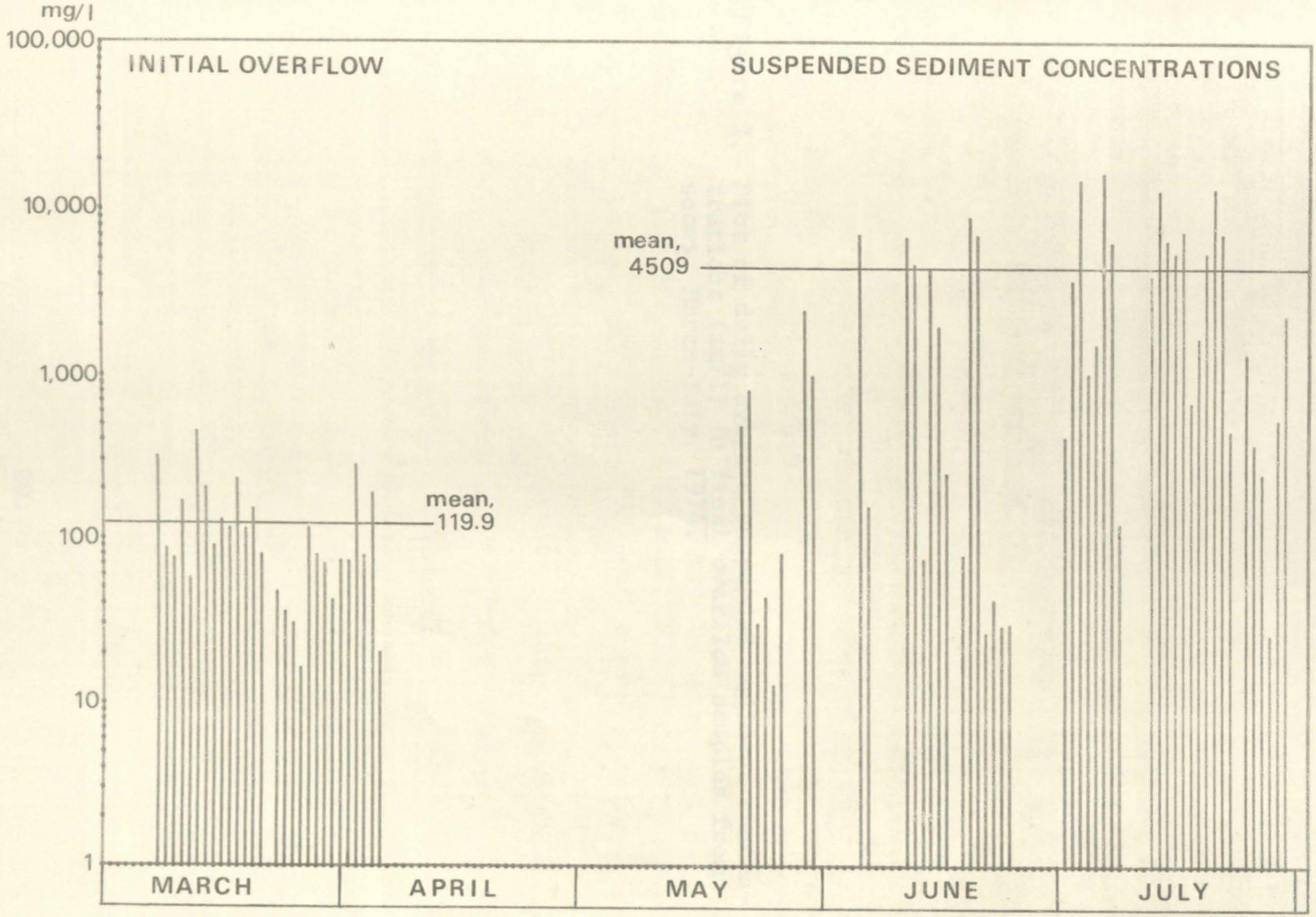
7/8/74 - Mid-Flood

Buoy	7	8	9	10
Surface	6.57	6.89	6.67	6.67
Bottom	6.20	6.27	6.47	6.37

7/8/74 - Late Flood

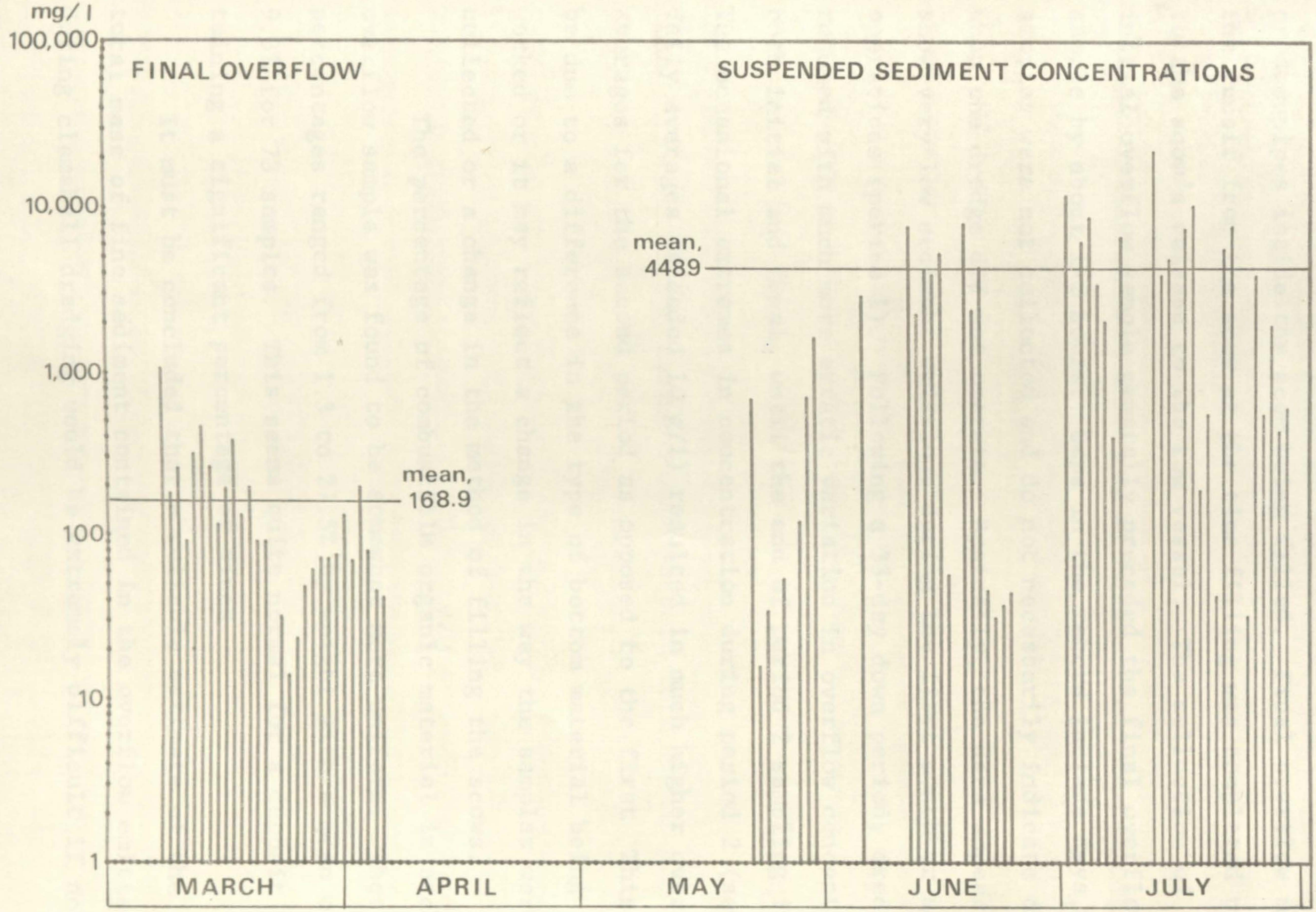
Buoy	7	8	9	10
Surface	6.69	6.81	6.75	6.95
Bottom	6.69	6.57	6.71	6.61

Figure 6. Plot of daily average suspended sediment concentrations (mg/l) in initial overflow samples from scows, March-July, 1974.



mg/l
100,000
10,000
1,000
100
10
1
INITIAL OVERFLOW
SUSPENDED SEDIMENT CONCENTRATIONS
mean,
4509
mean,
119.9
MARCH
APRIL
MAY
JUNE
JULY

Figure 7. Plot of daily average suspended sediment concentrations (mg/l) in <u>final</u> overflow samples from scows, March-July, 1974.


mg/l
100,000
10,000
1,000
100
10
1
FINAL OVERFLOW
SUSPENDED SEDIMENT CONCENTRATIONS
mean,
4489
mean,
168.9
MARCH
APRIL
MAY
JUNE
JULY

flow occurring shortly after the fluid level reached the gunnels or downpipes inside the scow being filled. Final overflow means the runoff from the scow at the time filling was completed prior to the scow's release to the tow vessel. The collection of the initial overflow sample generally preceded the final overflow sample by about 1-2 hours. Gaps in the record include days when samples were not collected and do not necessarily indicate days when the dredge did not operate. Basically, the data appear to show very low sediment emissions during the first month or so of operations (period 1). Following a 33-day down period, dredging resumed with much more erratic variation in overflow concentrations, both initial and final, until the end of period 2 sampling in July. The occasional extremes in concentration during period 2 (several daily averages exceeded 10 g/l) resulted in much higher overall averages for the second period as opposed to the first. This may be due to a difference in the type of bottom material being worked or it may reflect a change in the way the samples were collected or a change in the method of filling the scows.

The percentage of combustible organic material in each overflow sample was found to be somewhat more uniform. These percentages ranged from 1.3 to 27.5% by weight with a mean of 9.3% for 73 samples. This seems quite normal for a deposit containing a significant percentage of fines.

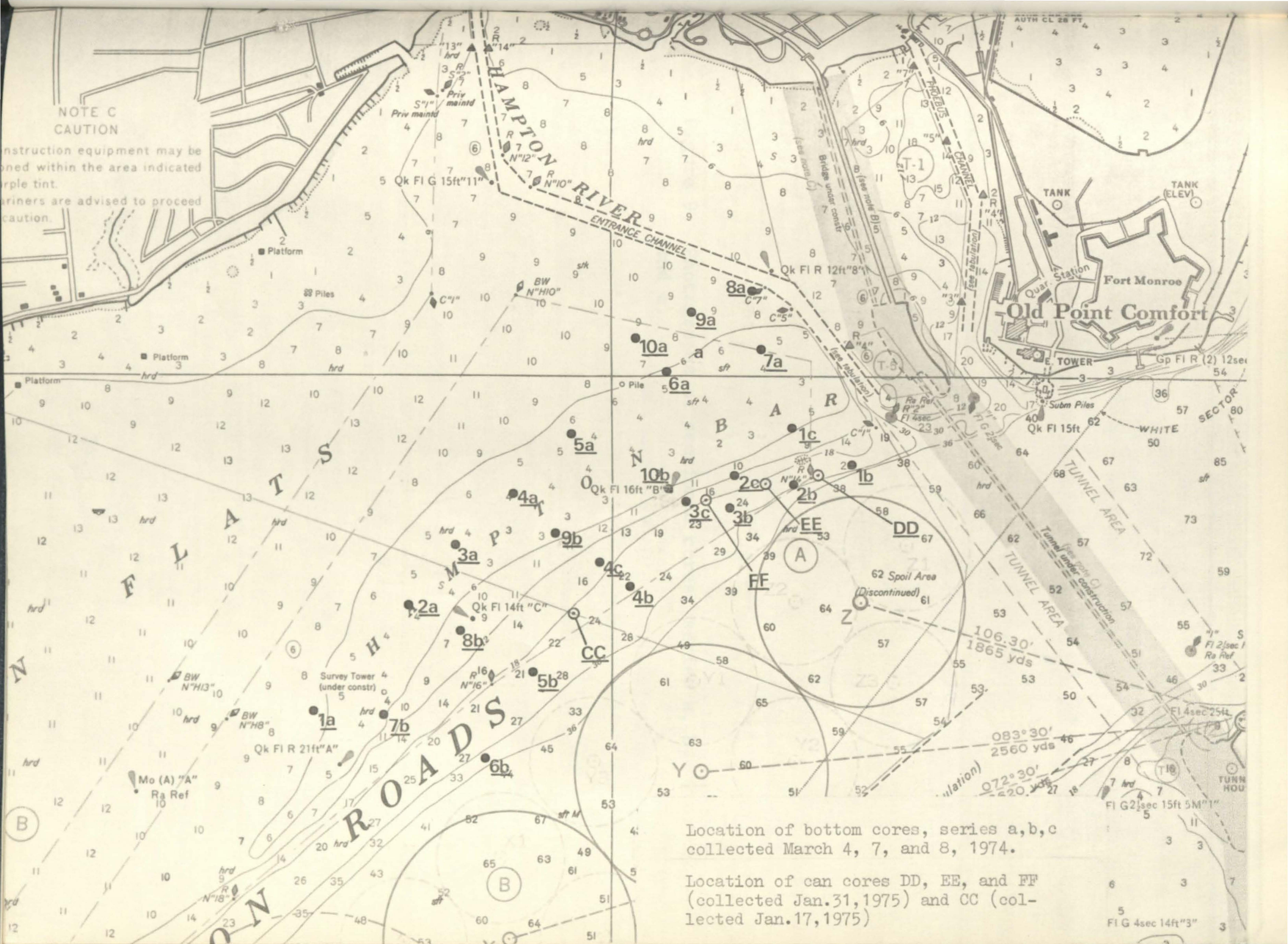
It must be concluded that a reliable estimate of the total mass of fine sediment contained in the overflow emitted during clamshell dredging would be extremely difficult if not impossible to obtain. Thus, although the yardage of useable fill is known for periods 1 and 2, no estimate can be made of the total suspended load that was introduced into the water column during this phase of the dredging.

Bottom Sediment Characteristics:

An initial sampling of bottom sediments in the vicinity of Hampton Bar was conducted on March 4, 7, and 8, 1974. A series of short cores were obtained at the locations shown in Figure 8 using a pole corer in shallow depths and a diver in depths greater than 10 feet. Special care was used in collecting and handling the cores to prevent any disturbance. The purpose for obtaining these cores was to 1) determine the general surface sediment type present on the bottom; 2) evaluate the recent depositional history of the upper few inches of the sediment column; and 3) note the appearance of the undisturbed sediment-water interface prior to dredging. Although our sampling post-dates the start of dredging operations, we were unable to discern any deposits suggestive of spoil accumulations during the brief interim.

Photographs of the sectioned cores are presented in Figure 9. All of the cores taken in the middle of Hampton Bar contain more than 95% fine to medium sand by weight. Those collected in deeper water at the bar margins contain a more pronounced matrix of silt. Cores 5b and 6b are characteristic of the southwest flank of the bar where coarse shell debris and hydroid colonies make up a large part of the bottom.

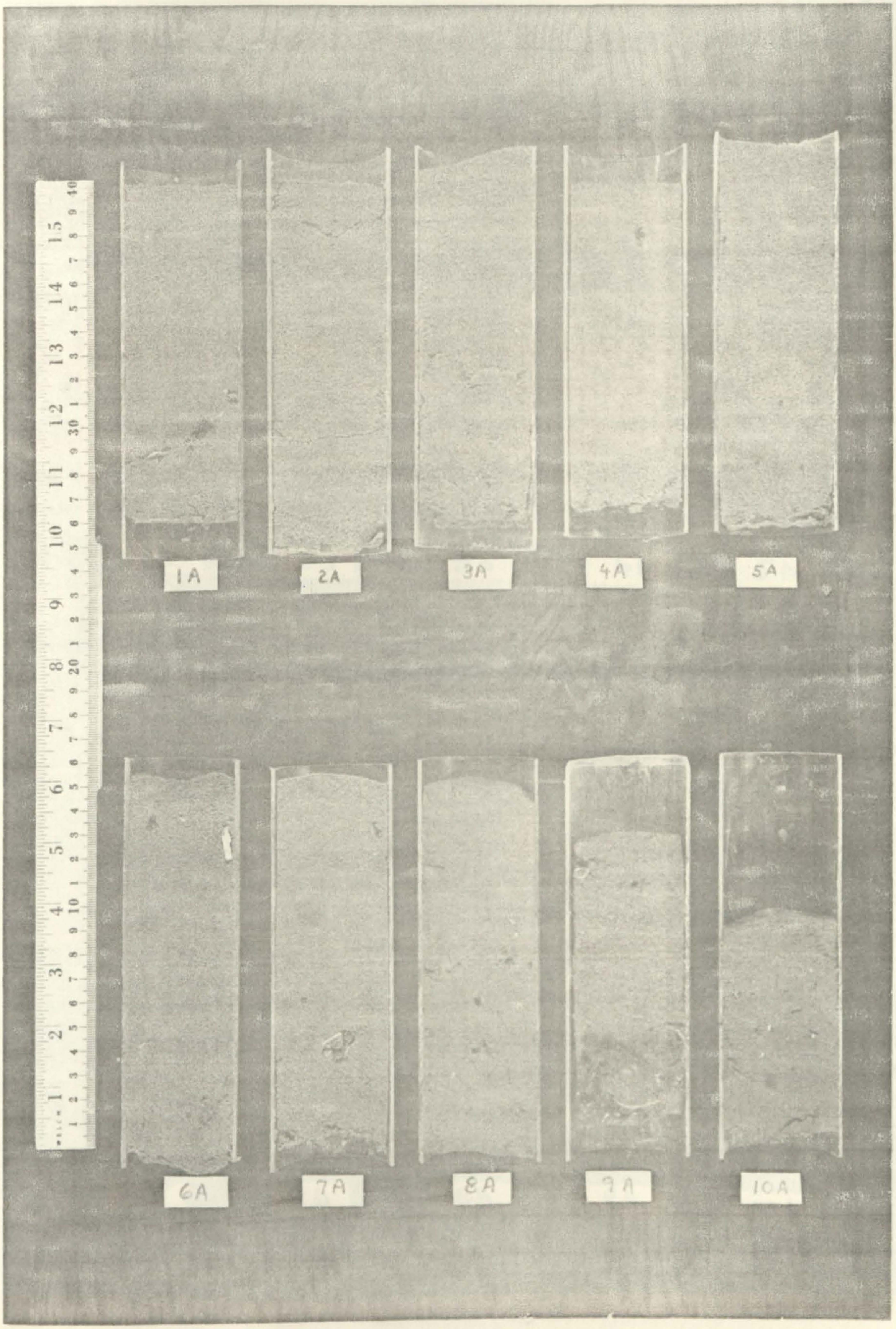
Figure 8. Location of initial core samples collected at Hampton Bar on March 4 (series a), March 7 (series b), and March 8 (series c), 1974; also can cores DD, EE, FF (Jan. 31, 1975) and CC (Jan. 17, 1975).

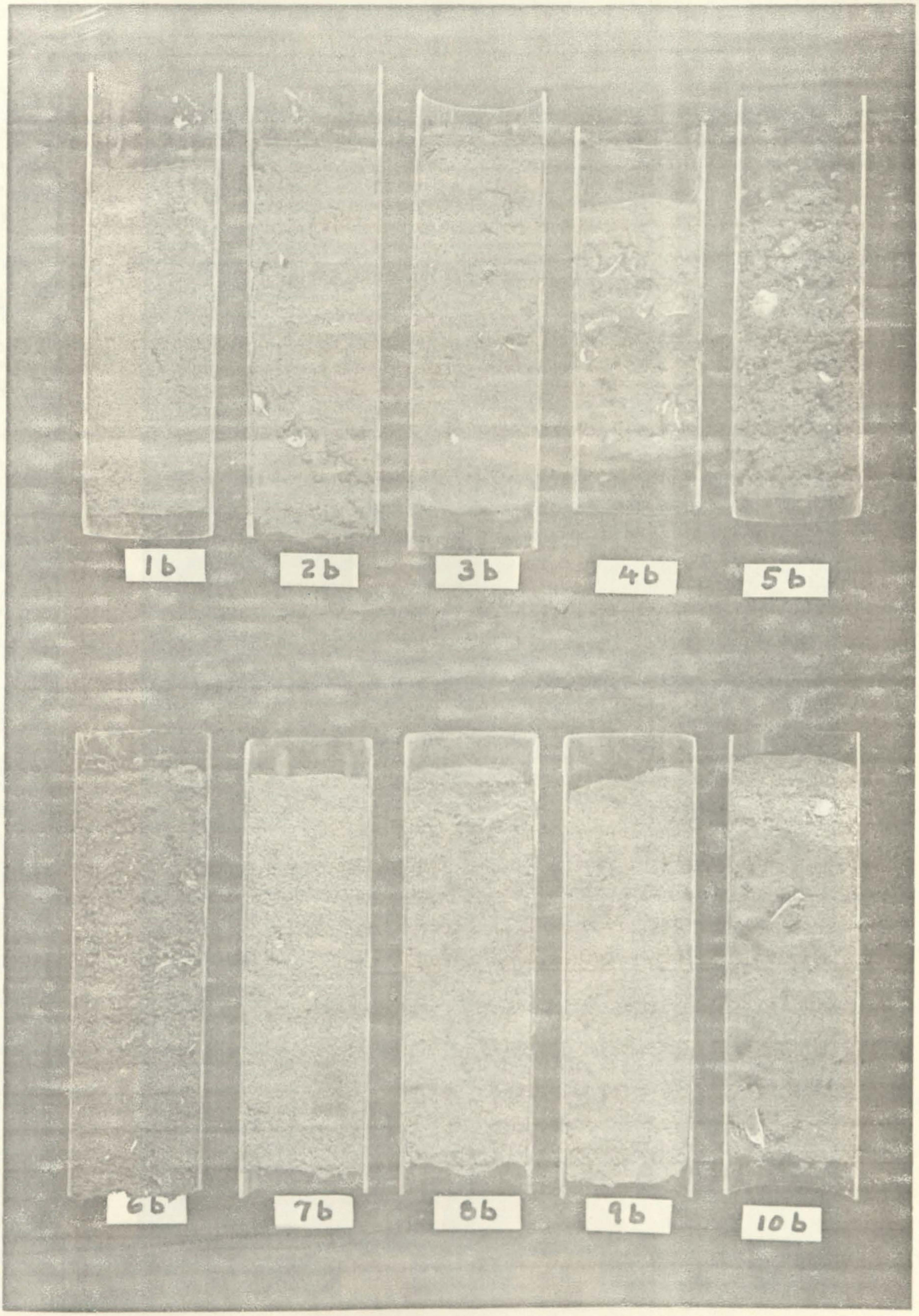


Location of bottom cores, series a,b,c collected March 4, 7, and 8, 1974.

Location of can cores DD, EE, and FF (collected Jan.31,1975) and CC (collected Jan.17,1975)

Figure 9. Photographs of sectioned cores, series a, b, and c.


1A
2A
3A
4A
5A
6A
7A
8A
9A
10A


1b
2b
3b
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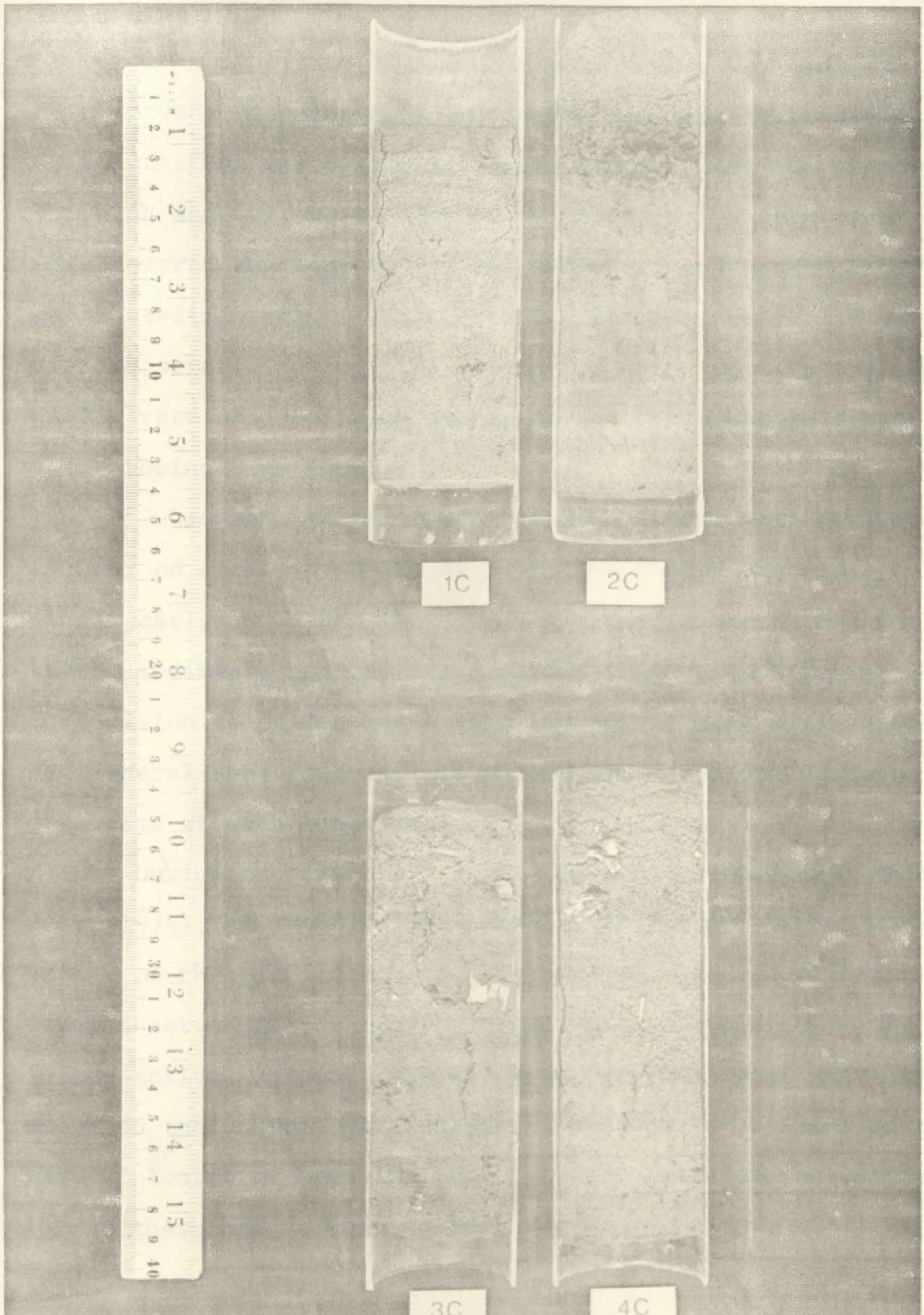
6b
7b
8b
9b
10b


1C
2C
3C
4C

In most of the core photographs a granular texture can be observed extending right up to the sediment-water contact. This interface was ordinarily quite smooth (with the exception of cores 5b and 6b) and in several of the cores, a thin algal matting covered the very top of the sediment, indicating a lack of active sedimentation. Only core 1c, in fact, contained any visible stratification, the absence of which usually indicates a slow rate of deposition and/or active bioturbation (reworking by burrowing organisms).

Subsequent to the above sampling, cores were collected by a diver on a regular basis at buoys 2-4 (outer bar), buoys 7-10 (inner bar), and other locations near the dredge to monitor the bottom sediments and their potential response to dredging emissions. In addition to collecting a core, the diver made observations of the general appearance of the bottom and noted the presence of organisms at each location.

During the first and second periods of dredging (through July, 1974), no evidence of unusual silt accumulation was seen at any of the buoy locations. At most of these locations the diver observed one or more clam siphons protruding from the bottom in the active "pumping" state. Numerous worm tubes were also noted on the bottom, particularly along the inner flank of the bar. Colonies of hydroids were commonly found on the bottom at the southern end of Hampton Bar.

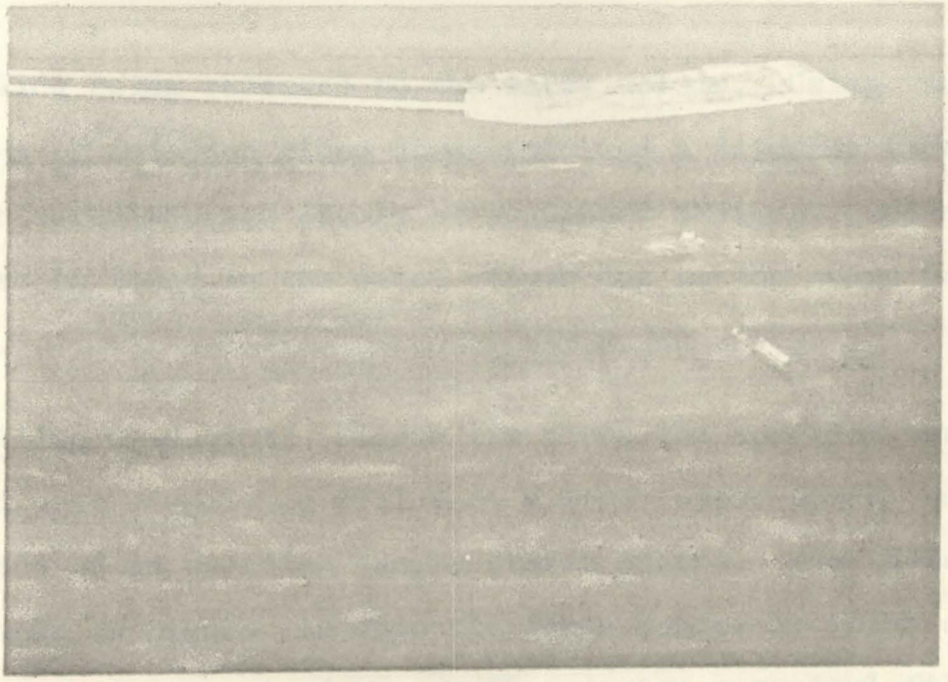
MONITOR OF EMISSIONS - PERIOD 3 AND 4

Comments on Hydraulic Dredging Method:

Periods 3 and 4, from 22 August, 1974, until 10 February, 1975, include all of the dredging on Hampton Bar conducted by hydraulic means. Figure 10 shows the hydraulic dredge Talcott in operation during a flood tide on August 29, 1974. As illustrated in the photos of Figure 10, two silt plumes were normally generated by this system; one emanated from the dredge near the cutter head and the other issued from the spreader barge at the end of the outfall pipe where the scows were filled.

The use of a hydraulic dredge to fill scows on site for later transport to a remote location is not a commonly used method. Although bottom materials may be removed more rapidly using a hydraulic as opposed to a clamshell dredge, the faster rate of delivery to the scow will still be offset by the number of scows available and the time required to recycle them. Thus, the Talcott required about ten operating hours to fill an average of 9-10 scows per day, leaving the dredge idle for the remaining portions of the day. One obvious advantage of the method, in terms of fill material quality, is that a large quantity of water can be pumped into the scow along with the fill which tends to wash out a greater percentage of fines. The beneficial refining of the deposit at the borrow site is, however, not as desirable from the environmental point of view. Consequently, it was deemed necessary to measure the approximate fraction of the total load

Figure 10. Aerial oblique photographs showing hydraulic dredger Talcott in operation during a flood tide, August 29, 1974.



per filling being released to the water column. Using rough estimates of emission plume dimensions and a dilution factor, we also estimated average levels of suspended sediment concentration likely to be found in the water column due to the above dredging methods.

Scow Filling Operation: Figure 11a shows the spreader barge manifold unit dispensing fill into a scow (upper photo) and the collection of an overflow sample (lower photo). The three photographs in Figure 11b show the three routes by which excess water and sediment exited as overflow during a typical filling operation:

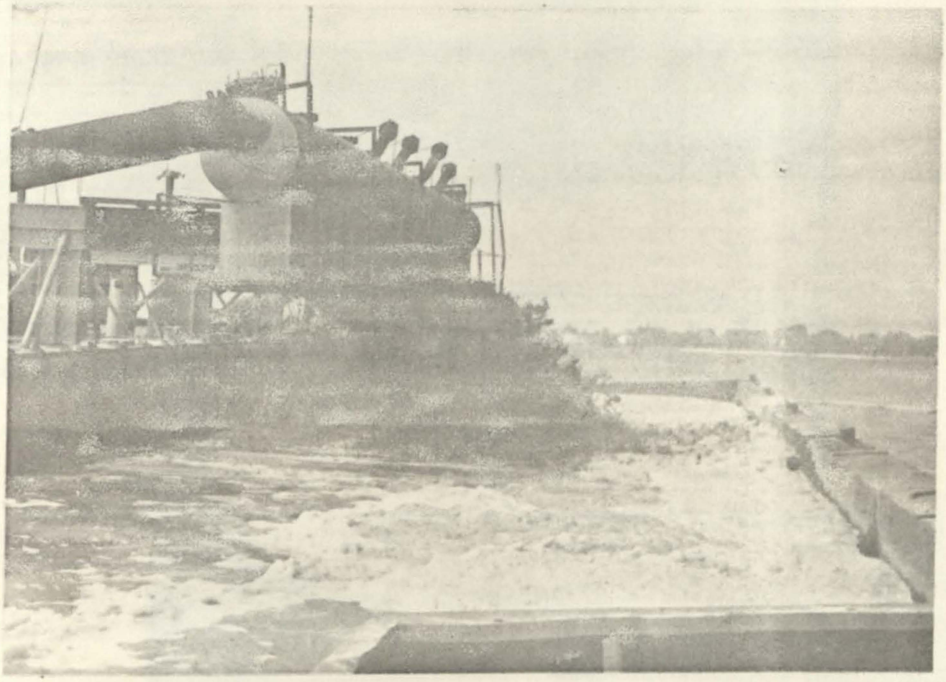
1) Downfall pipes - The upper photo, Fig. 11b, shows overflow entering one of six downfall pipes which pass through the hull and exit underneath the scow. Although the purpose of the downfall pipes is to direct solid emissions toward the bottom, the diameter of the pipes is far too small to accommodate the volume of fluid that was pumped into the scow at the height of the filling operation.

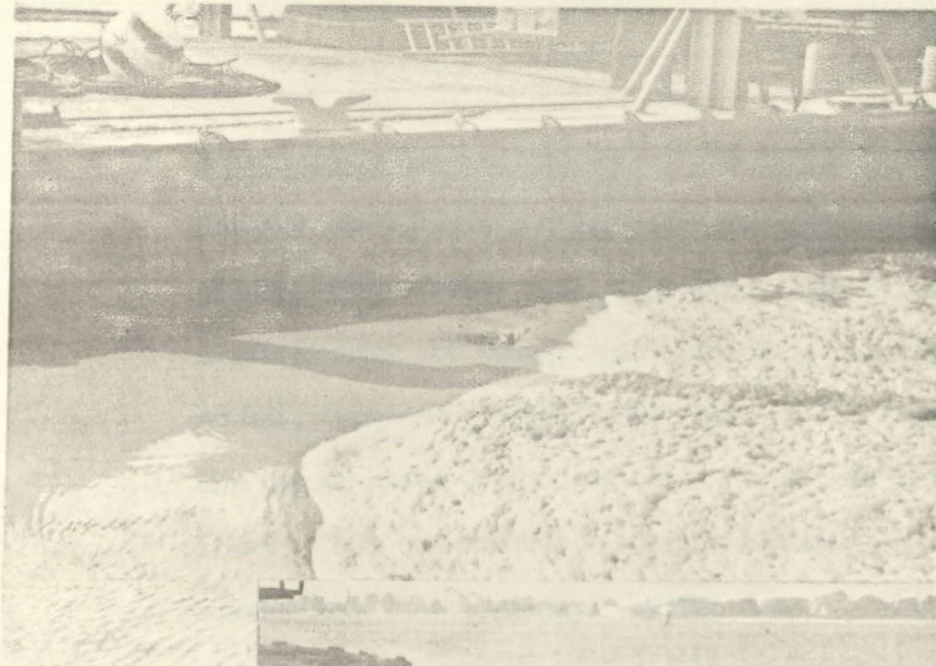
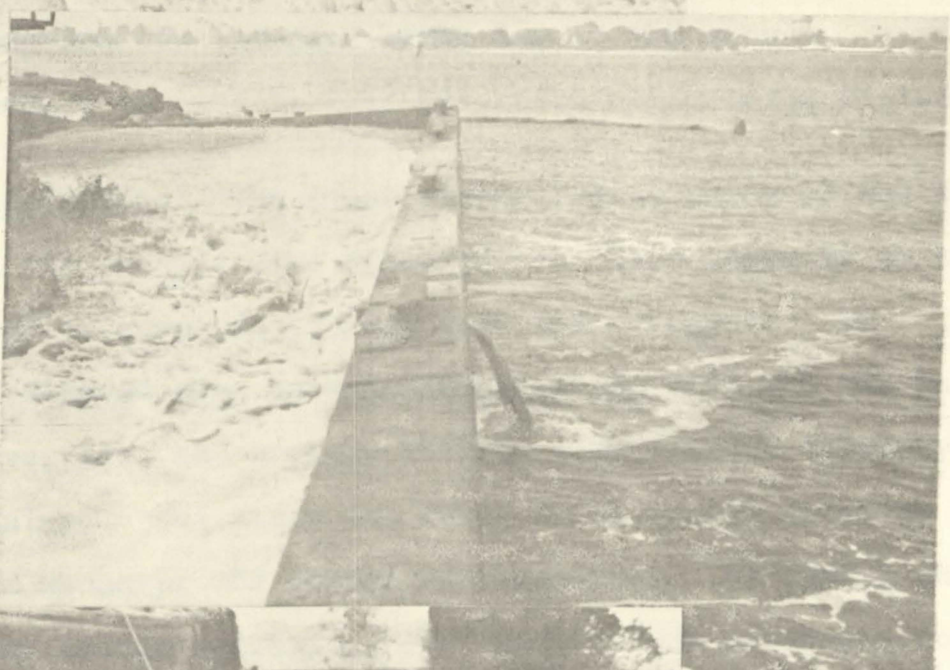
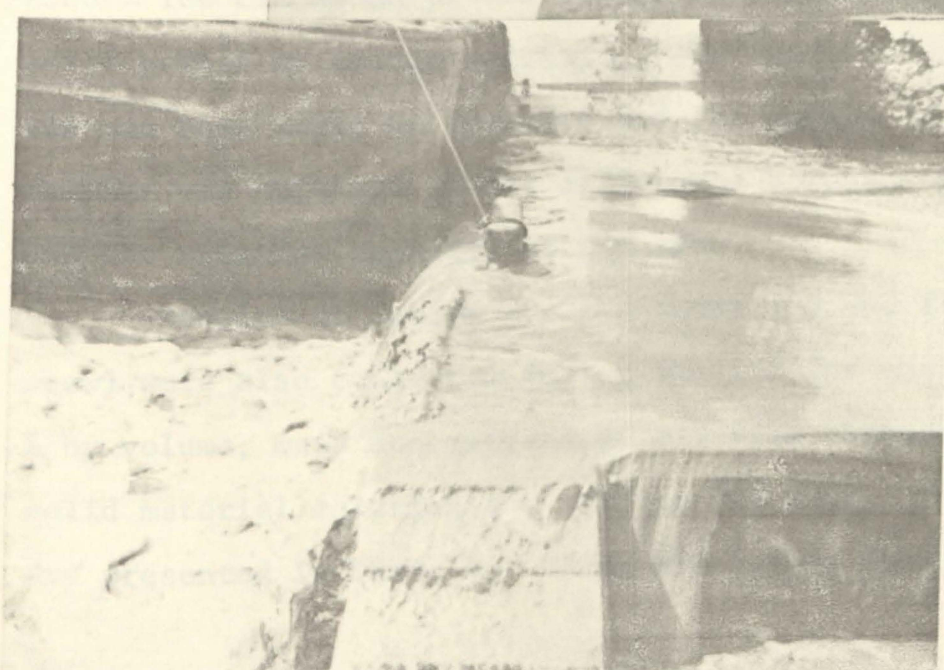
2) Bleeder pipes - Several small bleeder pipes (middle photo, Fig. 11b) pass through the gunnels of the scow at a point slightly lower than the tops of the downfall pipes. The amount of overflow conveyed was very limited.

Figure 11. Hydraulic scow filling operation:

a) spreader barge filling a scow; collection of overflow sample;

b) photos showing routes of overflow.



3. Sheet flow over gunnels - The majority of the overflow simply spilled over the top of the gunnels (lower photo, Fig. 11b) once the scow had filled to capacity. A surcharge of water and sediment continued to be added, however, until the sand fill accumulating in the scow came within a foot or so of the surface. Sheet flow normally passed over the inboard gunnels alongside the spreader barge due to the scow's tendency to list in that direction while being filled.

Discharge Calculations: The inner dimensions of three of the four scows used in the project were measured and their capacity at the moment of overflow computed (taking tilt into account). By measuring the elapsed time between starting the fill and the initiation of overflow, the average filling rate (dredge delivery rate) was obtained. This rate was found to be nearly constant at 2000 ± 100 cfm whenever the dredge was operating. By timing the total period of dredge operation, the total volume delivered to any one scow could be computed and the volume of overflow into the sea was obtained as the difference between the latter amount and the overflow capacity of the scow.

Samples of inflow (to the scow) and overflow (from the scow) were also collected during the filling operation to obtain % by volume, mass concentration, and size characteristics of the solid material entering and leaving the scow. The resulting data are presented in Table 4. Using the latter data and the calculated

Table 4. Averages of % solids (by volume), mass concentration, and sand-silt-clay ratio (by weight) in emission samples collected during scow filling operation.

INFLOW ENTERING SCOW

Date	Scow	No. Samples	% Solids	Conc (g/l)	Sand-Silt-Clay Ratio*
9/16/74	505	6	34.6	321.4	89.6:8.2:2.2
9/16/74	504	6	25.7	244.8	86.7:10.2:3.1
9/20/74	104	1	21.8	289.8	93.6:4.5:1.9
10/ 2 /74	504	5	28.2	278.4	90.3:7.0:2.7
10/18/74	504	3	27.8	284.0	91.5:6.1:2.4
2/ 7 /75	504	8	26.8	241.4	84.5:11.9:3.6
Weighted Average			28.4	271.1	88.0:9.1:2.9
Standard Deviation			± 3.5	± 31.3	

OVERFLOW LEAVING SCOW

Date	Scow	No. Samples	% Solids	Conc (g/l)	Sand-Silt-Clay Ratio
9/16/74	505	6	12.1	33.5	25.0:55.3:19.7
9/16/74	504	4	10.9	34.9	31.2:41.4:27.3
9/20/74	104	5	9.9	20.0	10.3:64.5:25.2
10/ 2 /74	504	6	10.6	30.4	26.8:51.4:21.8
10/18/74	504	5	12.4	38.5	26.5:57.5:16.0
2/ 7 /75	504	6	11.4	39.1	38.0:47.8:14.2
Weighted Average			11.2	32.8	26.5:53.2:20.3
Standard Deviation			± 0.9	± 6.4	

* Sand: $>$ 1/16 mm grain diameter
Silt: 1/16 - 1/256 mm grain diameter
Clay: $<$ 1/256 mm grain diameter

volumes of inflow and overflow, the net discharge of solids and the overflow/retention ratio of solids were computed as given in Table 5.

The amounts listed in Table 5 are subject to a measurement error of about ± 10%; however, we can say with some confidence that the average loss of solids to the water column was about 25-30% of the total load extracted. The fact that most of the material lost was smaller than sand size is reflected in the shift of the sand-silt-clay ratio between inflow and outflow samples; the former contained almost 90% sand by weight whereas the latter contained slightly more than 25% sand on the average. It should also be noted that the average mass concentration of the hydraulic overflow (32.8 g/1) is considerably higher than the corresponding mean for the clamshell dredge overflow (1.7 - 4.5 g/1).

Dispersal of Overflow in the Water Column: The visible plume emanating from the dredge during and after a filling operation can usually be traced quite well by means of color contrasts or tonal variations in aerial photographs. However, tonal variations reflect the turbidity or optical density of the upper few inches of the water column and not the amount of sediment actually contained per unit of volume - the mass concentration.

In Table 4, we report mass concentrations of suspended solids in the overflow from scows in the range of 20-40 g/1,

Table 5. Net discharge of solids and overflow/retention ratio of solids.

1. Scow 505 - 9/16/74

Inflow:	4000 x .284	=	1136 cu. yds.	
Overflow:	3156 x .112	=	353 " "	(31% of inflow)
Retained in Scow			783 " "	

Overflow/Retention Ratio = 0.45

2. Scow 505 - 9/16/74

Inflow:	4000 x .284	=	1136 cu. yds.	
Overflow:	3156 x .112	=	353 " "	(31% of inflow)
Retained in Scow			783 " "	

Overflow/Retention Ratio = 0.45

3. Scow 104 - 10/2/74

Inflow:	3778 x .284	=	1073 cu. yds.	
Overflow:	2981 x .112	=	334 " "	(31% of inflow)
Retained in Scow			739 " "	

Overflow/Retention Ratio = 0.45

4. Scow 504 - 10/2/74

Inflow:	3259 x .284	=	926 cu. yds.	
Overflow:	2415 x .112	=	270 " "	(29% of inflow)
Retained in Scow			656 " "	

Overflow/Retention Ratio = 0.41

5. Scow 504 - 10/18/74

Inflow:	2630 x .284	=	747 cu. yds.	
Overflow:	1786 x .112	=	200 " "	(27% of inflow)
Retained in Scow			547 " "	

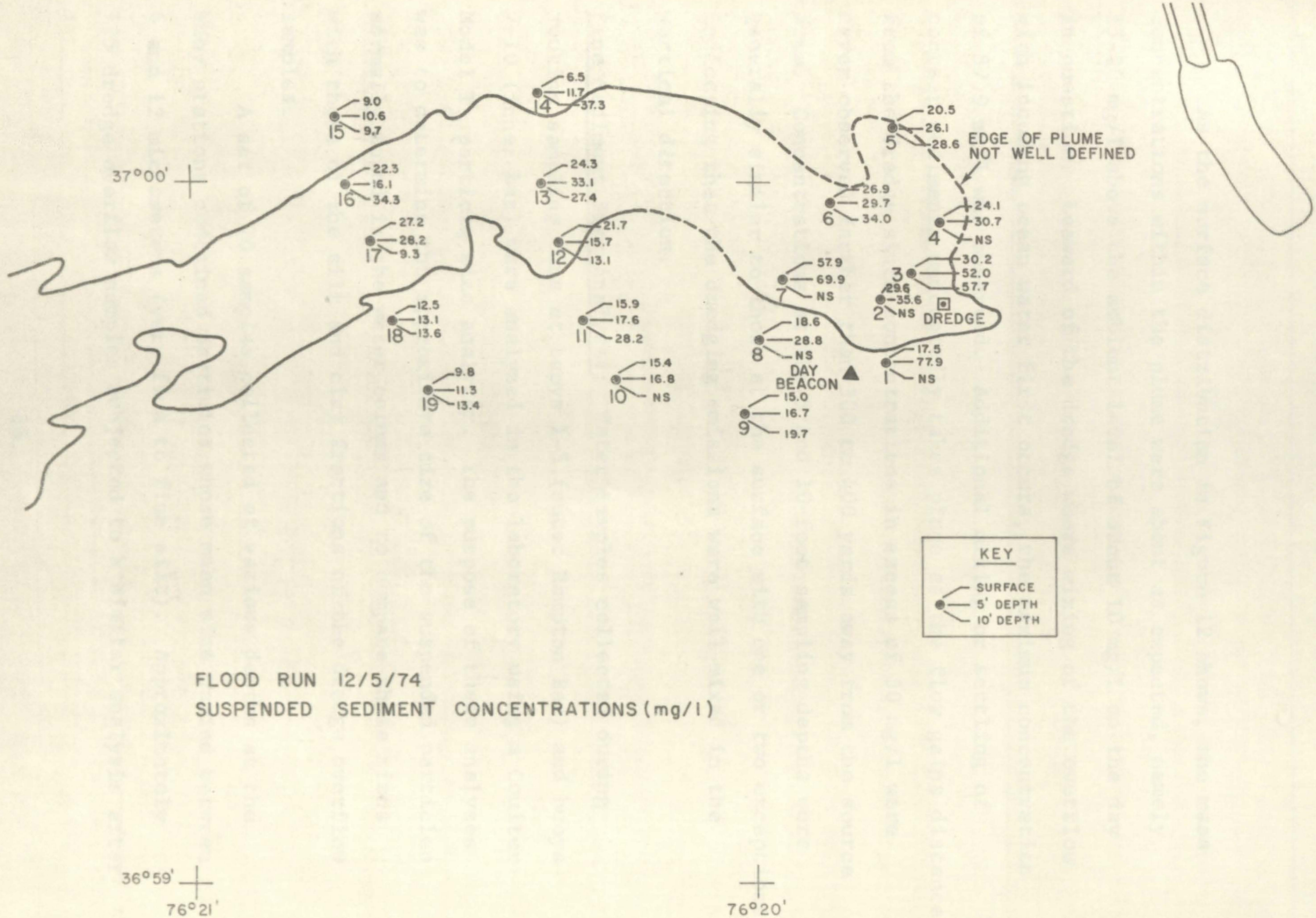
Overflow/Retention Ratio = 0.37

or about 33 g/1 as an overall average. Considering an average volume of overflow to be about 3000 cu. yds. (2.3×10^5 1), this is equivalent to a release of 7.45 long tons (7570 kg) of sediment, about 75% of which will be silt and clay.

From our aerial observations we noted that an average flood plume when fully developed would be on the order of 4000 yards long and perhaps 400 yards wide. If we suppose that this plume extends downward 9 feet (approximately the average depth on Hampton Flats) and that all of the silt and clay from an average release were evenly dispersed within the plume, the mass concentration therein would be about 15 mg/1 above ambient levels, or equivalent to a dilution factor of 1/1600. Similarly, a dilution factor of 1/800 would yield a 30 mg/1 mass concentration. These are very rough approximations to be sure, but they show the order of magnitude of the concentration level increase to be expected due to dredging, assuming that none of the finer sediments settle out of suspension while the plume is being generated and assuming that lateral diffusion and mixing is negligible.

Observed Distribution of Solids in the Water Column: A flood plume produced on 5 December, 1974, was recorded in an overlapping series of near-vertical, 70mm aerial photographs. A mosaic made from contact prints permitted accurate mapping of the plume in relation to known ground control points. Water samples were collected within one hour of the photography along five transverse sections crossing the plume at varying distances from the emission source. The resulting concentration data was then compared with turbid water distributions as shown in Figure 12.

Figure 12. Comparison of suspended solids concentrations with turbid plume photographed December 5, 1974.



FLOOD RUN 12/5/74
SUSPENDED SEDIMENT CONCENTRATIONS (mg/l)

As the surface distribution in Figure 12 shows, the mass concentrations within the plume were about as expected, namely 15-20 mg/l above the ambient level of about 10 mg/l on the day in question. Leeward of the dredge where mixing of the overflow with incoming ocean water first occurs, the maximum concentration of 57.9 mg/l was observed. Additional mixing or settling of coarser sediments undoubtedly takes place as the flow gains distance from the dredge since concentrations in excess of 50 mg/l were never observed farther than 300 to 400 yards away from the source area. Concentrations at the 5 and 10-foot sampling depths were generally similar to those at the surface with one or two exceptions, indicating that the dredging emissions were well mixed in the vertical direction.

Fine Sediment Size Analyses: Water samples collected during routine sampling runs at buoys 1-5 (outer Hampton Bar) and buoys 7-10 (inner bar) were analyzed in the laboratory using a Coulter Model T_A particle size analyzer. The purpose of these analyses was to determine the approximate size of the suspended particles normally found in the water column and to compare these sizes with those of the silt and clay fractions of the dredge overflow samples.

A set of 70 samples collected at various depths at the buoy stations contained particles whose mean size varied between 6 and 12 micrometers (very fine to fine silt). Approximately 125 dredge overflow samples subjected to a similar analysis after removal of the sand fraction indicated mean particle sizes varying randomly between 5 and 25 micrometers (very fine to medium silt) with generally poorer sorting than that of the buoy samples. No trends or vertical gradations in suspended particle size could be detected among these data. Also, it was not possible to distinguish any significant difference between the sizes of particles emitted by dredging and those occurring naturally in the water column.

MONITOR OF BOTTOM DEPOSITION

Can Cores: Beginning in late September, 1974, can cores were used to sample the top few inches of the bottom in lieu of the short 2-in. cylindrical cores used at the buoy sampling stations up until that time. A can coring device is simply a one-gallon can of the type used to hold paint thinner which has been cut off near the base. A diver pushes the can into the bottom with the screw cap removed (to allow water to escape), then replaces the cap and inserts a plywood board underneath the core before lifting it out of the bottom. The core is then extracted from the can and sectioned in the laboratory. Can cores show a much wider section of the sediment column as compared to standard tube cores.

Outer Bar Deposition: Four examples of can core sections are shown in Figure 13. These cores were collected in January of 1975 in about 20 feet of water along the channel side of Hampton Bar at the positions indicated in Figure 8. At this time, the dredge was operating about 200 yards NW of day marker "B" near the channel margin or about 500 yards NW of core FF.

In passing from core DD to core FF, recent changes in the rate of deposition and reworking of bottom material become increasingly evident. These changes were not unexpected since the cores came from locations close to the overflow zone of the spreader barge as the latter moved from east to west. All three cores show pronounced stratification featuring alternation of

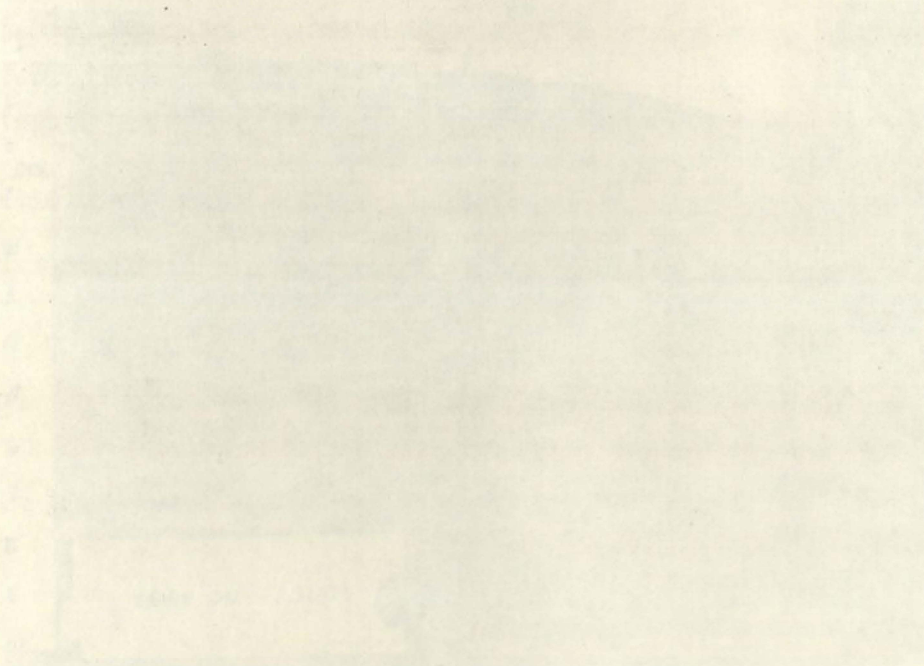
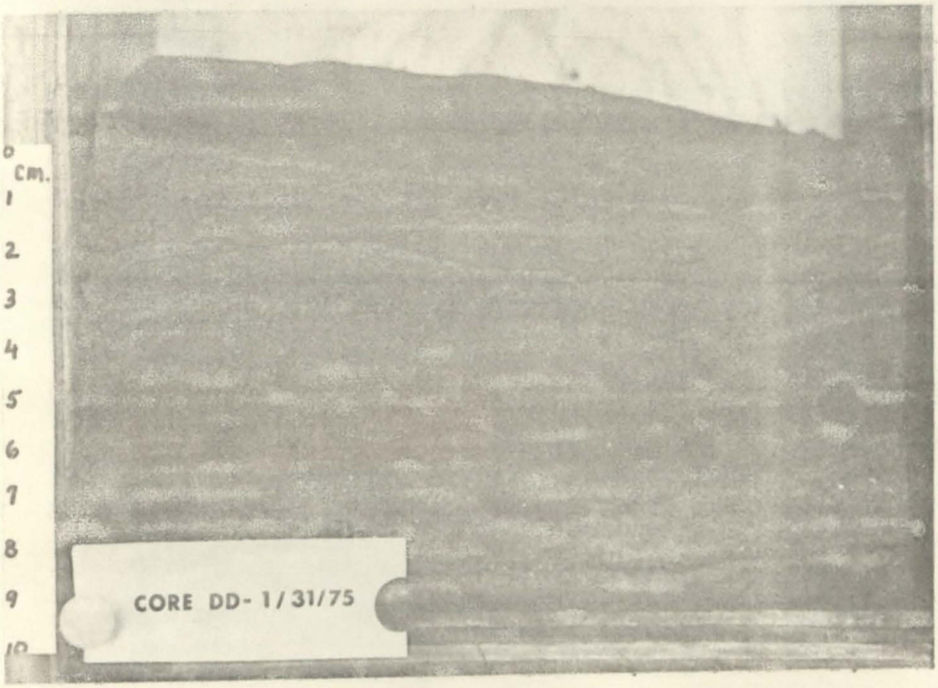


Figure 13. Can cores collected along channel margin of Hampton Bar at the locations shown in Figure 8.



cm.
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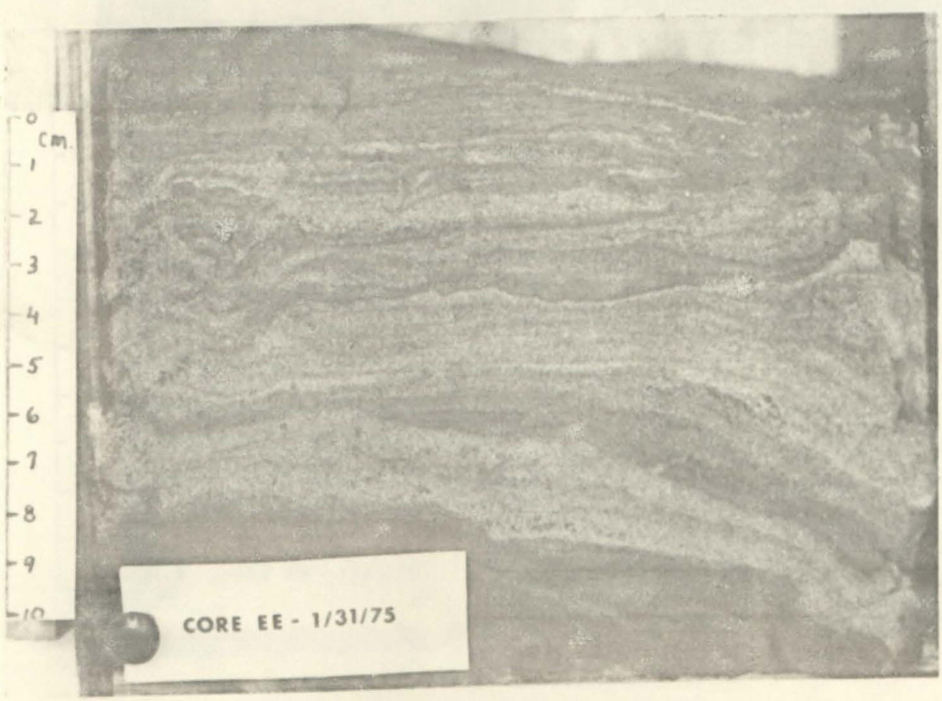
CORE DD- 1/31/75



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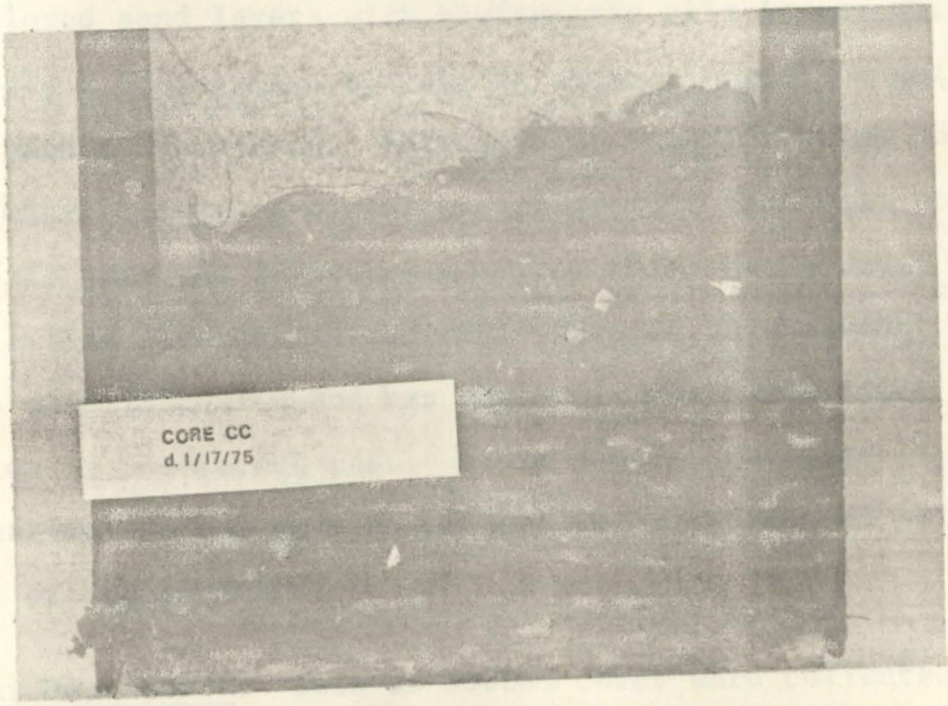
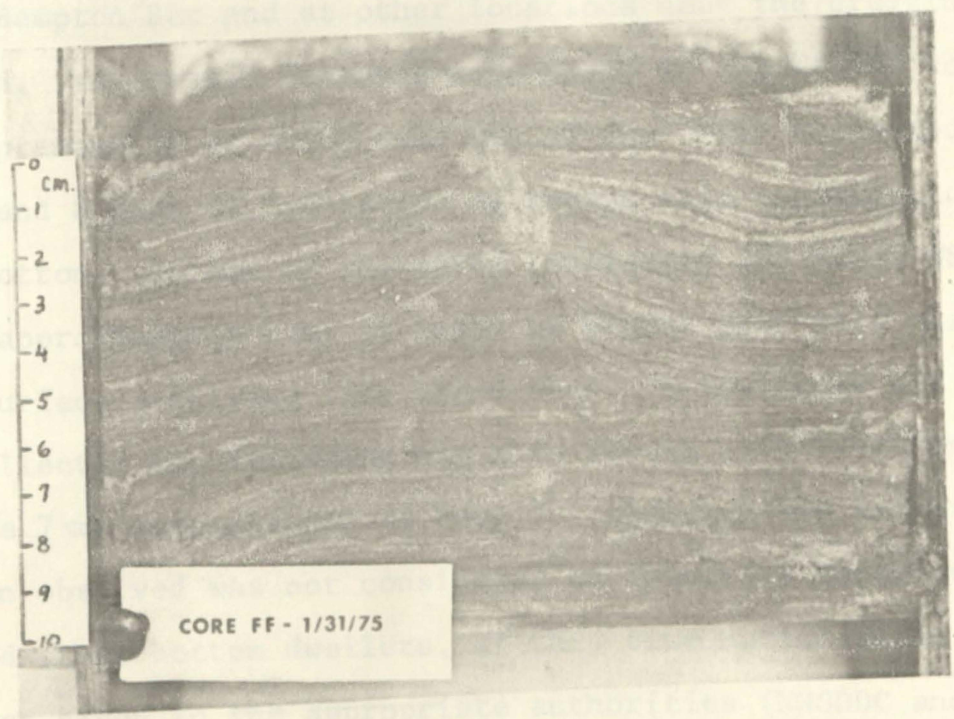
CORE EE - 1/31/75


CORE CC
d. 1/17/75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CORE FF - 1/31/75

light-colored sand layers with bluisy-gray silt layers which is undoubtedly a consequence of varying types of overflow emissions having reached the bottom. This type of stratification does not persist where burrowing organisms are present that will soon destroy it; note the filled clam burrow which has already disturbed the fine layering in core FF. Core CC to the west contains no stratification and has obviously received little or no deposition in the recent past. Other samples obtained in deeper water outside the bar gave no indication of pronounced stratification or deposition.

Inner Bar Deposition: Sets of bottom cores were collected about every three weeks at buoy stations 7-10 on the shallow inner side of Hampton Bar and at other locations near the dredging operation. No unusual features were noted in any of the cores until September 23 at which time two of the cores collected near buoys 7 and 8 gave an indication of recent silt accumulations on the bottom. In one of the cores (collected 350 yards SSW of buoy 7), approximately 5 mm (¼ inch) of bluish-gray silt was found at the surface overlying fine brown sand. A replicate set of can cores collected the following day also showed silt layering, including a 7 mm accumulation at buoy 7. Although the amount of siltation observed was not considered an immediate hazard to hard clams and other bottom dwellers, at this time notification of the change was given to the appropriate authorities (NNSDDC and Corps of Engineers) as a precautionary measure. Subsequent sampling revealed no further increase in the thickness of silt deposits and no detectable accumulations were found between October 21 and November 25 when the dredge again left the area. Also, none of the sediments sampled during this time gave any unusual indications of reducing conditions such as would be indicated by dark organic colorations and a strong odor of hydrogen sulphide.

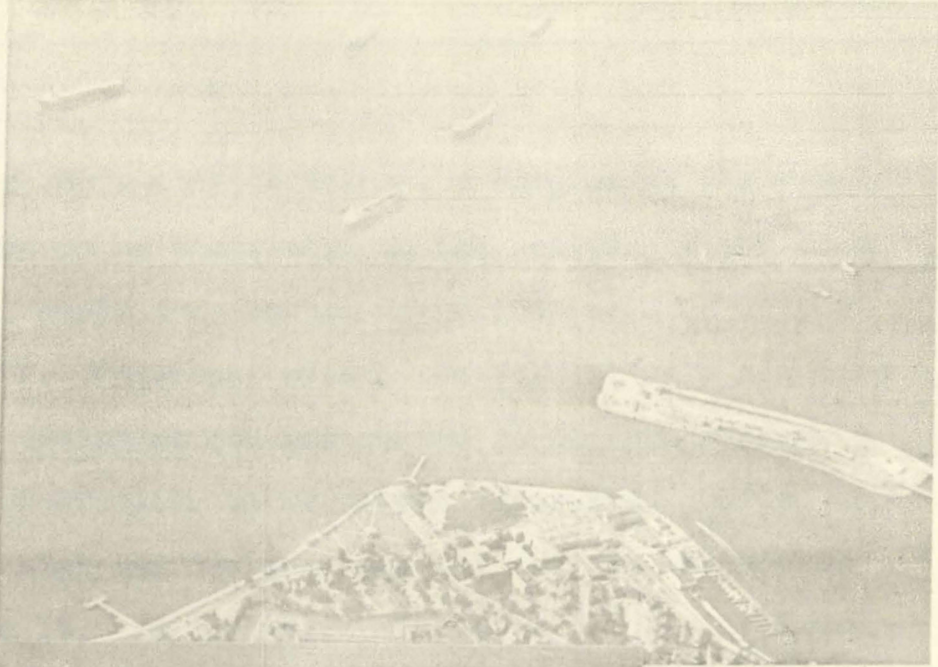
As a footnote deserving mention at this point, our diver reported sightings of numerous clam siphons projecting above bottom during most of the station visits. The majority of the sightings were of the angelwing clam Cyrtopleura costata (Linne, 1758) which is commonly found in silty nearshore bottoms. This clam is usually indicative of stable bottom conditions since the adult organism occupies a permanent burrow some 10-12 inches below the sediment-water interface and cannot tolerate more than an inch or so of added sediment overburden.

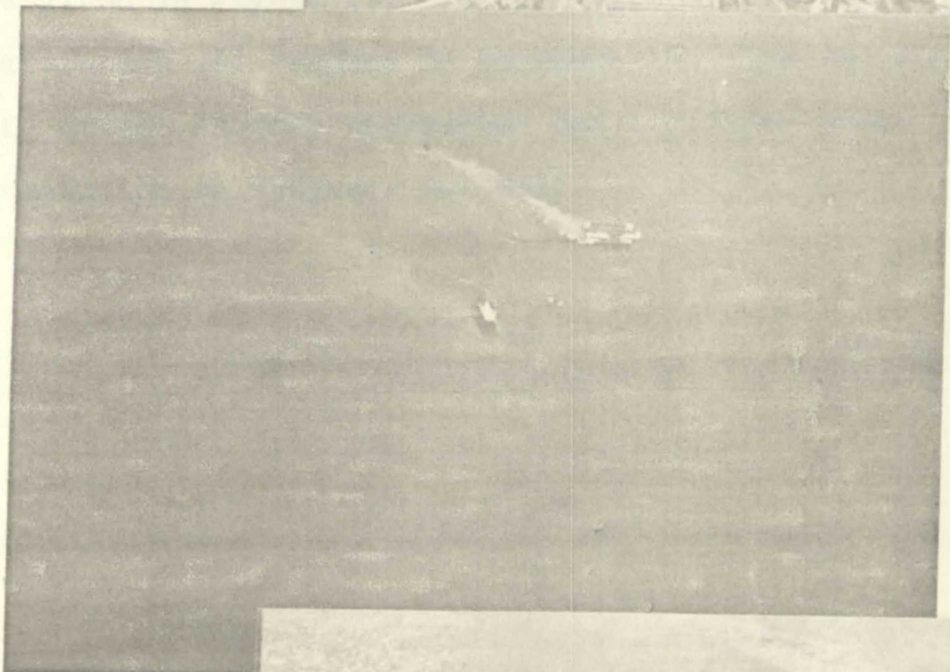
RESTRICTIONS ON DREDGING ACTIVITY

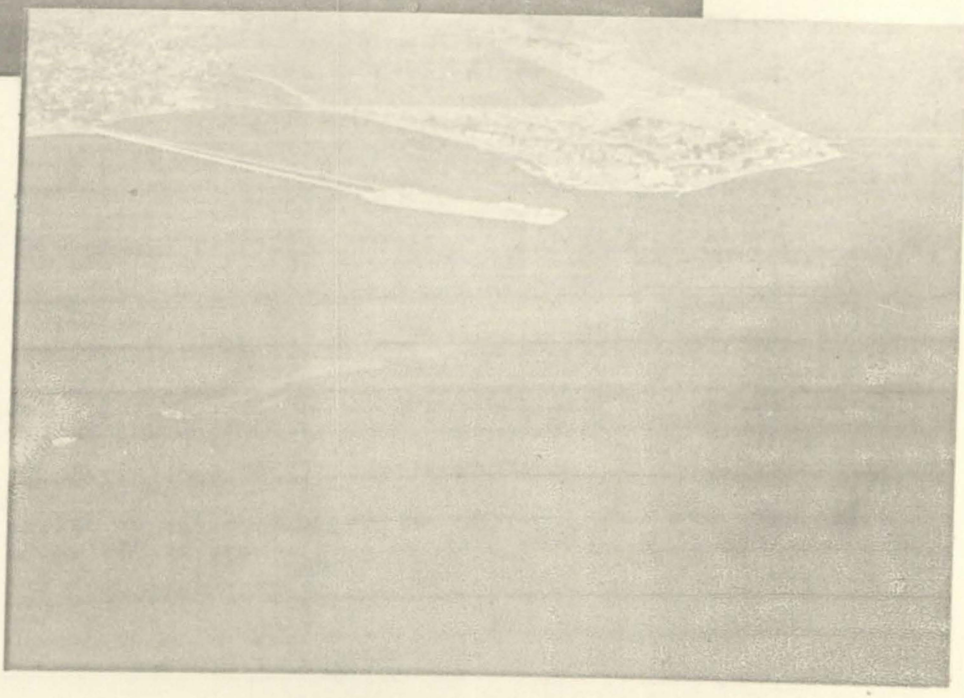
Ebb Only Restriction: The silt accumulations on the inner bottom of Hampton Bar occurred shortly before a drop in water temperature at the site from a daily mean of 70.7°F on September 30 to a mean of 61.3°F on October 20, 1974. During this time, a recommendation was made by VIMS biologists to the effect that dredging activity should be terminated upon reaching bottom water temperatures of 50°F or less. The rationale behind this recommendation considers the fact that most benthic organisms have sharply reduced metabolic rates below 50°F and cannot free themselves from any overburden of sediment added once they are in a dormant state. While in agreement with this reasoning, we concluded on the basis of our observations of the prevailing patterns of emissions dispersal that no significant bottom siltation would occur if dredging could be restricted to ebb current phases.

During the ebb phase of the tidal cycle, the plume generated by dredging on Hampton Bar would normally set to the east where deep water and high velocity, turbulent flows within the Hampton Roads channel would aid in mixing and dispersing the suspended load within the plume. Turbulent flows also tend to reduce the rate of settling of fine sediments, keeping them in suspension over greater distances. Water sampling conducted within an ebb plume tended to confirm this hypothesis when it was found that suspended sediment concentrations were only slightly higher than ambient levels at distances greater than 1000 years downstream from the point of emission. A typical emission during an ebb phase can be seen in the photographs in Figure 14.

Figure 14. Aerial oblique photographs of hydraulic dredge _Talcott_ operating during ebb tidal phase.



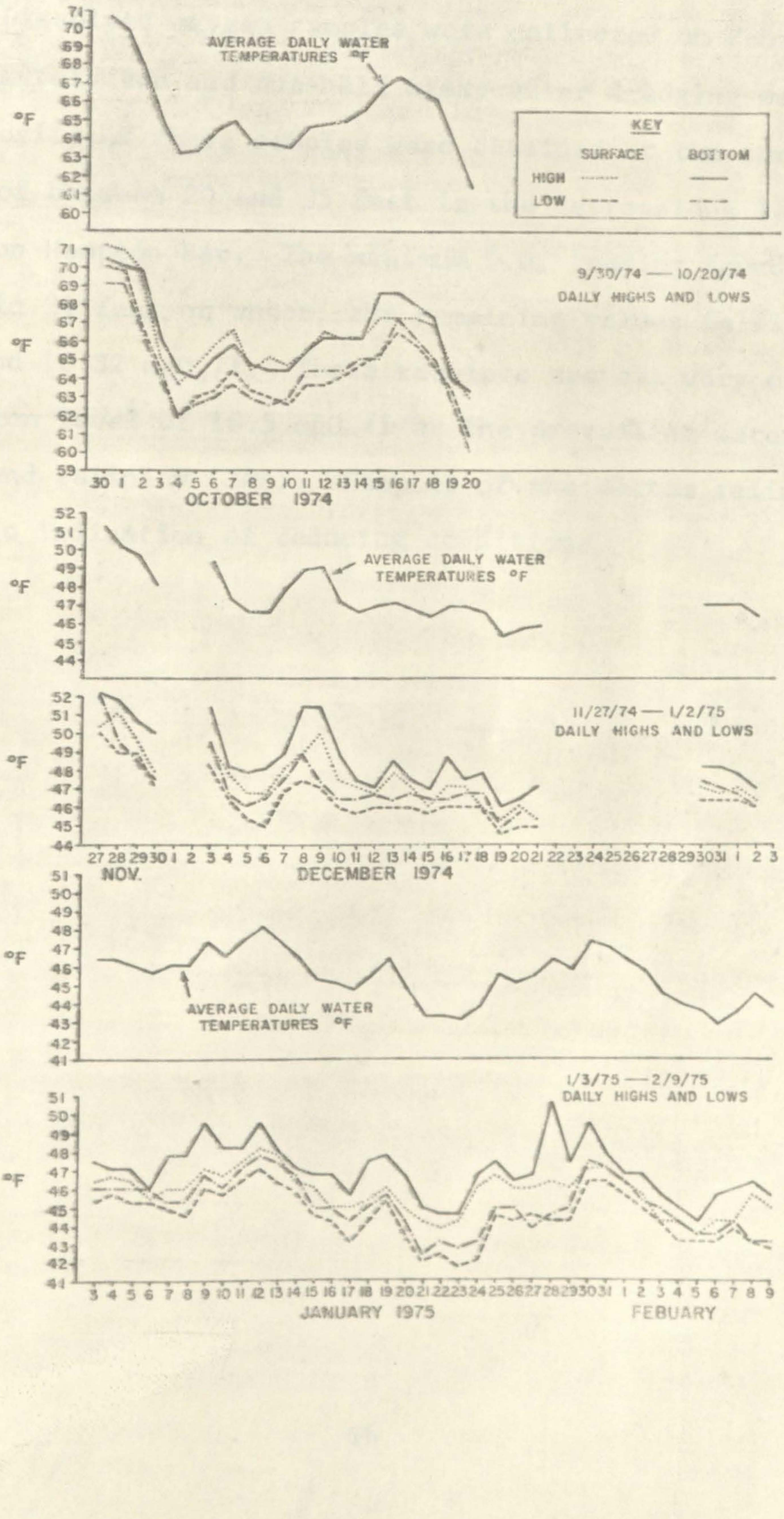




Based on the above considerations, a compromise was reached wherein dredging was to be restricted to the periods of ebb flow in each daily tidal cycle once bottom water temperatures at the site fell below 50°F. Personnel aboard the Talcott were provided with the necessary equipment and instructed to measure surface and bottom water temperatures at four-hour intervals. Daily averages and daily high and low readings for surface and bottom are given in Figure 15. As indicated in Figure 15, the minimum temperature was reached on November 28. The restriction went into effect shortly thereafter and continued until the project's termination on February 10, 1975.

Figure 15. Daily average water temperatures and daily high-low readings for surface and bottom at borrow site.

DAILY WATER TEMPERATURES °F AT HAMPTON BAR



Post-Dredging Dissolved Oxygen Levels

Dissolved oxygen samples were collected on February 28, 1975, approximately two and one-half weeks after dredging was terminated. The majority of these samples were obtained at the surface and at depths of between 20 and 25 feet in the depressions left by the dredge on Hampton Bar. The minimum D.O. reading found was 9.25 mgO_2/l in 24 feet of water, the remaining values falling between 10.09 and 10.32 mgO_2/l. These readings are all very close to the saturation level of 10.5 mgO_2/l at the prevailing water temperature (47°F) and salinity (24‰). Samples of the bottom sediments contained no indication of reducing conditions.